A MANUAL

OF

THE GEOLOGY OF INDIA.

PART IV: MINERALOGY.

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PART IV:

MINERALOGY

(MAINLY NON-ECONOMIC).

BY

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PREFACE.

WHILE the first and second parts of the present work, by Mr. H. B. Medlicott and Dr. W. Blanford, treat on the general geology of India, or the physical, stratigraphical and palæontological geology of the country, the third part, by Mr. V. Ball, is devoted to the economic geology of the same region. The scope of the last, as indicated by the word 'economic,' while including all Indian minerals which are capable of useful application in the arts, necessarily excluded those which do not possess any such economic value. The main object of the present, or fourth, part is to present some account of the latter class of minerals, and is therefore, in some respects, supplementary to Part III. Mention is, indeed, made of all known Indian minerals, in order to bring into one view an outline sketch of the entire subject; but, except in those cases where the acquisition of fresh information since the issue of Mr. Ball's work, or other reason, has rendered a departure from the general rule desirable, only the briefest allusion is made to such as have been previously described. A reference, in all such cases, to Part III, shows where much fuller information is to be obtained.

In looking through the following pages, some will probably be struck with the comparatively small amount of accurate knowledge we possess respecting non-useful minerals in India, considering the immense extent of the empire. One of the main reasons for this is to be found in the rarity of extensive mines, or other excavations, under intelligent supervision. The only metalliferous mines, at present worked under European superintendence, are the gold mines of Madras, and one or two of copper in Bengal. In many parts of the

country there are native iron, copper, lead, and other mines; but they are carried on with little or no system, generally on a trifling scale, and invariably by men who know nothing of minerals beyond a rule-of-thumb acquaintance with the one or two ores they may have been accustomed to work. The splendid zeolites which were obtained from the Deccan trap, at the tunnels and cuttings on the Great Indian Peninsula Railway, and the saline minerals discovered by Dr. Warth when Superintendent of the Mayo Salt Mines, show what might be expected were mining operations carried on in this country on the same scale, and with the same system, as in Europe and America. In some cases, however, but little mineralogical variety is, probably, to be anticipated from the metalliferous rocks. Thus, most, at least, of the known copper ores of India occur as a constituent of schistose rocks, and not in lodes, the depositories in Europe of such numerous minerals and magnificent crystals. The Báraganda copper mine, in Hazáribágh, may be cited as a case in point. Although now opened out to a depth of 300 feet, and giving a promising yield of copper-pyrites, nothing else has been obtained of any special mineralogical interest.

It may further be added that there is no demand in India for minerals *as* minerals purely. There is not a single dealer in mineral *specimens* in the country, and hence there is no incentive to the native miners to interest themselves in varieties unfamiliar to them.

Thus, a large proportion of our knowledge has been derived from such observations as could be made, and such specimens as could be obtained, on the surface. The number of workers, too, has not been very large. The Officers of the Geological Survey have necessarily been those most favorably placed for the acquisition of new information, but others have not been wanting who have devoted their leisure to the same object, and who have added most valuable contributions. In some cases, however, zeal would appear to have unfortunately exceeded the preliminary knowledge necessary for accurate determination, and it is to be feared that there are many statements in print which are not wholly trust-

worthy. More especially does this remark apply to the Madras presidency. In the "Indian Journal of Arts, Sciences, and Manufactures,"[1] long lists are given of minerals said to have been found in various districts. Some of these minerals had been previously described by authors whose writings are quoted in the following pages, but respecting a large proportion of the remainder, little information, or none, is given beyond the mere statement of their occurrence. Even this, however, would be most useful could the account be accepted as reasonably trustworthy. That there is a large amount of valuable information in the lists, the present write does not doubt, but as there is internal evidence of a considerable, but unknown, amount of error, he has considered it the lesser of two evils to omit them from amongst the authorities quoted.[2]

Within the next year or two the mineralogy of Upper Burma will probably be much better known than at present, and interesting results may be expected from a scientific examination of the ruby and other mines. The information respecting them available to the present writer is mostly contained in works published many years ago.

The system of classification adopted in the present work is that of Professor Dana, as given in his 'System of Mineralogy.'

No attempt has been made in the following pages to describe the occurrence, in individual localities, of the commoner minerals, which are to be met with in innumerable places. Indeed the materials do not exist for compiling such lists, even if they were worth publishing. In describing the combinations shown by crystals, the faces are, as far as possible, given in the order of their development,

[1] Part IV (1850), pp. 249, 257; Part VI (1851), p. 431; Part VIII (1851), p. 577; Part IX (1852), p. 636, 2nd series, Vol. I, No. 1 (1854), p. 27; No. 2 (1856), p. 50.

[2] The same remark may be made with reference to a paper on the Geology of Madura and the adjoining districts (Madras Journal of Literature and Science, Vol. XVII, p. 90). Although minerals in abundance are mentioned, many of them rare species, nothing beyond the mere statement of their occurrence is said with reference to most of them, and not a word is added as to how, or by whom, their specific identity was determined. During a subsequent examination of part of the same area, by the Geological Survey, none of these rare minerals were observed.

the predominant ones being mentioned first. The figures were drawn by the writer, in some cases from figures or descriptions previously published, but mostly from crystals now in the Geological Museum.

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MANUAL OF THE GEOLOGY OF INDIA.

PART IV: MINERALOGY.

I.—Native Elements.

Series I.—The more basic, or electro-positive elements.

1. Gold group.

Gold.—Gold-bearing rocks are widely spread over immense tracts of country in India. Occurring, as it does, in nearly every province of the empire, the metal is the subject of a bulky literature and has been very fully treated by Mr. V. Ball in Part III of the present work. The only important additions to our knowledge since its publication in 1881, are due to the operations of the gold-mining companies of the Madras presidency, at that time in their infancy. The unsatisfactory results obtained by so many of these show that much of the auriferous quartz contains but a low proportion of metal—a fact indicated by the following abstract of the published returns up to the first quarter of 1883[1]:—

	Quartz treated.	Total yield.			Yield per ton.			Remarks.
	Tons.	Oz.	dwt.	grs.	Oz.	dwt.	grs.	
A	3,597	482	0	11	0	2	16	Treated by 6 S. E. Wynaad Cos.
B	1,200	45	0	0	0	0	18	Poorest lot included in A.
C	323	160	18	12	0	9	23	Richest lot included in A.
D	504	152	0	0	0	6	1	Treated by 3 Kolar Cos.
E	50	2	10	0	0	1	0	Poorest lot included in D.
F	44	40	10	0	0	18	10	Richest lot included in D.

On the other hand, the encouraging results obtained by the Mysore gold-mining company, in Kolar, conclusively show that the quartz in portions, at least, of some reefs, is highly auriferous. During the first ten months of 1885, 3,759 ounces of bar gold was produced from 1,390 tons of stone, or 2 oz. 14 dwt. per ton; and the yield, in October, from 169 tons was at the rate of 4 oz. 2 dwt. Two picked specimens of quartz,

[1] The Indian Gold-mining Industry, by D. E. W. Leighton, 1883, p. 29.

weighing respectively 2½ and 7lb, from the above company's mines, which were exhibited at the Colonial and Indian Exhibition in 1886, were thickly spangled with visible gold. The assay of a portion of the smaller piece indicated about 570 oz. to the ton.[1]

In January 1885 a specimen, weighing about 80 grains, was sent to the Geological Museum in Calcutta by Dr. J. R. Stratton, Political Agent at Jaipur. It is composed mainly of cleavable, semi-transparent calcite, with malachite in minute acicular crystals, and is thickly spangled with gold. The specimen is said to have been originally obtained from one of the copper mines at Khetri, in Rájputána. "Regarding it" (Dr. Stratton wrote) "the story, now almost a legend, is that copper ore was being mined when some was found with the gold-like particles in it, and that, on further mining, the white rock with similar particles was reached. But as it was a time of disorder, with Pindáris, &c., abroad, the mine was at once closed, from fear that the rumour of a gold mine might bring an enemy to Khetri." The locality is one from which gold had not been reported previously, and the specimen is remarkable from the unusual matrix in which the metal occurs.

The following analyses of native gold from Upper Burma have been recently published by Dr. Romanis.[2]

A.—Rather large irregular grains; from foot of hills in the Meza valley, 30 miles west of Katha:—

	Gold	87·66
	Silver	5·96
Gangue	Copper pyrites	1·95
	Silver	1·54
	Magnetite	0·32
	Quartz	1·09
	Loss on ignition	1·48
		100·00

B.—Small smooth grains; from the sand of the Meza river:—

Gold	74·83
Silver	2·86
Platinum (with trace of iridium)	2·53
Iridosmine	7·04
Zirconia	7·08
Silica (by diff.)	5·66
	100·00

Silver.—The gold of India, like that of other countries, is alloyed with a varying proportion of silver, and the latter has occasionally been met

[1] The geological character of the Mysore gold-bearing rocks has been discussed by Mr. R. B. Foote, in the Records, G. S. I., Vol. XV, p. 191.

[2] Records, G. S. I., Vol. XIX, p. 268.

with, in the native state, in association with the more precious metal, but not as yet in more than trifling quantity (Pt. III, p. 233).

2. Iron group.

Platinum.—Platinum has been found, in association with stream gold, in several parts of India (Pt. III, p. 167), being, as far as we know at present, more plentiful in Burma than elsewhere. None, however, appears to find its way into commerce. The gold-washers, being ignorant of its value, usually reject it as useless;[1] hence our knowledge as to the productiveness of the platiniferous sands is not as accurate as might be wished.

A sample of stream gold from the Meza valley, in Upper Burma, recently analysed by Dr. Romanis, contained 2·53 per cent. of platinum (with a trace of iridium) in admixture.[2]

In 1882 minute grains of platinum were noticed in stream gold from the Guram river, near Dhadka in Mánbhum, from Lándu in Chaibassa, and from the Bráhmini river in the tributary mehals of Orissa. But in all cases the amount of platinum was extremely small, being not more than a trace in comparison to the accompanying gold.[3]

Dr. R. Saunders records that he "extracted 12 per cent. of refuse from some gold dust" (from Tibet between Eastern Bhutan and the Sangpo river), "and on examination found it to be sand and filings of iron, which last was not likely to have been with it in its native state, but probably employed for the purpose of adulteration." Was the supposed iron platinum? The former metal would be a very clumsy adulterant of gold on account of its colour.[4]

Platiniridium (?)—In 1831 a button, obtained by the fusion of metallic grains "having every appearance of iron," which were found mixed with stream gold from the Kyendween (Chindwin) river, in Upper Burma, were submitted to analysis by Mr. J. Prinsep, who obtained—

Platinum	25
Gold	5
Iridium and osmium	40
Iron	10
Arsenic and lead	20
Rhodium (?)	...
Palladium (?)	...
	100

[1] Major Burney has stated this with reference to Burma (Asiatic Researches, Vol. XVIII, Pt. 2, p. 281), and Mr. Baden-Powell in connection with the Indus valley (Punjab Products, Vol. I, p. 14).

[2] See "Gold," p. 2.

[3] F. R. Mallet: Records, G. S. I., Vol. XV, p. 55.

[4] Turner's Embassy to Tibet (1800), p. 405.

The lead he considered had been added to render the more intractable metals fusible, while it may perhaps be inferred that the gold was stream gold which had not been separated from the platinum metals. A sample of the original ore subsequently examined by Mr. Prinsep was found to contain about 20 per cent. of platinum and twice as much iridium, the remainder appearing to be chiefly oxide of iron.[1] This ore is noticed by Professor Dana as platiniridium.[2] But it seems far more likely that it was a mixture of platinum and iridosmine, both of which are known to occur, with stream gold, in Upper Burma.

Iridosmine.—This alloy has been noticed, along with platinum, in stream gold from the Noa-Dehing river, in Upper Assam. It occurs in small lead-gray scales, which, from their colour, and loss of lustre before the blowpipe, seem to belong to the variety of the mineral called sisserskite.[3] As much as seven per cent. of iridosmine has been found, by Dr. Romanis, in stream gold from the Meza river, in Upper Burma.[4] It is called *shin-than* (clear iron) by the gold-washers, but they reject it as useless, so that, as Dr. Romanis says, a much larger proportion might perhaps be obtained by due care.

Mercury.—Although the discovery of this metal has been reported more than once, its occurrence in India is still open to doubt (Pt. III, page 170). According to Dr. R. Saunders, "Cinnabar, containing a large portion of quicksilver, is found in Tibet," by which probably the portion between Eastern Bhutan and the Sangpo river, where he travelled, is meant.[5]

Copper.—Perhaps the most remarkable specimens of native copper hitherto found in India were those obtained in Káshmir, from the lower part of the Zánskar river, where it flows through tertiary rocks. In 1878 several water-worn masses of pure metal, reaching up to 22lb in weight, were discovered in the bed of the stream, and were subsequently, when in the possession of the Governor of Ladákh, seen by Mr. R. Lydekker.[6] There is a specimen in the Geological Museum (weighing about 21 oz.) cut from a lump of some 20lb. Although nearly all solid copper, it includes a little cuprite, especially on the sides of one or two cavities: 120 grains of the metal was tested for silver and found to contain a

[1] Gleanings in Science, Vol. III, p. 39; Asiatic Researches, Vol. XVIII, Pt. 2, p. 284. The ore is described as consisting of "shining scaly grains of a silver colour, and dark black grains," which, although partially dissolved apart, were not subsequently analysed separately. It seems possible that the large amount of iron was due to the black grains being partly ilmenite, or other difficultly soluble oxide. Mr. Prinsep himself speaks of the analysis as imperfect.

[2] System of Mineralogy, p. 11.

[3] F. R. Mallet: Records, G. S. I., Vol. XV, p. 53.

[4] P. 2.

[5] Turner's Embassy to Tibet (1800), p. 405.

[6] Records, G. S. I., Vol. XIII, p. 40; Memoirs, G. S. I., Vol. XXII, p. 334.

minute trace only. The source whence the nuggets came has not been traced, but recollecting how frequently native copper is connected with trappean rocks, as in the well-known lake Superior mines, the conjecture may perhaps be hazarded that the vicinity of the trappean intrusions which occur between the tertiary and carboniferous strata of the Markha valley, is one of the most likely localities for the copper to have been washed from.

Native copper has been reported as occurring in a mine near Chitráni, and also near Jerri, in Kulu. It is said to form a "lode" at the latter place.[1]

Captain Drummond obtained some specimens, together with red oxide, which were said to have been brought from the hills of Goorgee Mydan, not far from Acoorookhail, in the Ghilzie territory of Northern Afghánistán. He himself obtained the native metal, with cuprite and chalcocite, at Tezeen,[2] and Dr. J. E. Aitchison a few years ago discovered some small loose pieces on mount Karátiga near the Shutargartan, in the same country.[3]

"Two very beautiful specimens of virgin copper in mammellated concretions" were received by Mr. J. Prinsep from the Singhána mines in Rájputána,[4] and the same ore is said to have been occasionally found in small pieces in Ajmere.[5] It is recorded that Captain Sherwill sent specimens of native copper, "from near the fort of Burdee on the Soane river," to the Asiatic Society's museum, in 1852.[6] A copper-bearing locality is marked on his geological map of Bengal about a mile south of the village. But, as remarked by Mr. Ball, the spot in question is on lower Vindhyan rocks, which are not otherwise known to be cupriferous.[7] The specimens, now in the Geological museum, bear a marked resemblance, in their association with crystallized quartz, and their being pitted with pseudomorphous cavities after the latter mineral, to certain other specimens from Cornwall, and it may perhaps be suspected that the report of copper at Burdee originated in some misplacement of labels.

Metallic copper has been noticed in Lándu, and one or two other mines in Singhbhum. It occurs in massy rosettes and flakes, but is rare. Mr. Stœhr says that it is only found where surface water can penetrate, and that it is associated with malachite, from which it seems to have been reduced.[8]

[1] Kulu: its beauties, antiquities, and silver mines. By J. Calvert, pp. 56, 60.
[2] Jour. As. Soc., Bengal, Vol. X, p. 77.
[3] Proc. As. Soc., Bengal, 1880, p. 4.
[4] Jour. As. Soc., Bengal, Vol. IV, p. 582.
[5] R. Irvine: Topography of Ajmere, p. 169.
[6] Jour. As Soc., Bengal, Vol. XXI, p. 361.
[7] Pt. III, p. 258.
[8] Report on the Copper Mines of Singhbhum, by C. Durrschmidt, pp. 14, 20; Records, G. S. I., Vol. III, p. 89.

There are five specimens of crystallized dendritic copper in the Geological museum, aggregating about 4 oz. in weight, which are said to have been found in the sand on the bank of the Damuda river, 6 miles above Rániganj. The spot is on Damuda (coal-measure) rocks, and if the specimens were washed down from the metamorphic area, they must have travelled many miles, in which case it is difficult to understand their being found so close to each other. Traces of copper have occasionally been detected in coal,[1] as a constituent, probably, of the pyrites, and it is conceivable that the Rániganj copper may have been due to long-continued oxidation, solution, and reduction of such.

Mr. P. Vanstavern has informed us that he possesses a fine specimen of native copper from a mine situated between Chinur and Warangal in Hyderabad. The person who gave it to him told him that he had seen pieces as large as a man's head quarried out from the workings, which are merely superficial.

"Faint traces of native copper" have been found in the old lead mines at Jungumrajpilly in the Kadapah district, Madras.[2] A few pieces of cupriferous veinstone, containing the native metal along with other ores, were noticed by Mr. H. F. Blanford in a stream south of Veppur, in the Trichinopoly district, but their source was not traced.[3]

Specimens obtained at Round island, near Cheduba on the Arakan coast, in 1843, were pronounced to be native copper.[4] They are now, however, in the Geological museum, and their examination, a few years ago, showed that they are artificial bronze.[5]

Lead.—Metallic lead has been observed partially filling small cavities in specimens of lead carbonate, found near Maulmain in Burma. The carbonate has a bright red colour, apparently due to an intimate admixture of minium; and Mr. G. H. Law, by whom it was sent to Calcutta, in reply to enquiries on the point, stated that it is "natural and not artificial."[6] In a subsequent letter Mr. Law mentioned that several pieces of lead, up to a pound in weight, had been obtained by digging a little below the surface, in the bank of a stream near Maulmain. It would be unsafe, however, without further investigation, to accept them as native.

[1] Daubree: Ann. des Mines, 4th series, Vol. XIX (1851), p. 669; Percy's Metallurgy, Fuel, &c., p. 276.

[2] W. King: Memoirs, G. S. I., Vol. VIII, p. 270.

[3] *Ibid.*, Vol. IV, p. 216.

[4] Jour. As. Soc., Bengal, Vol. XII, pp. 333, 904, 914.

[5] F. R. Mallet: Records, G. S. I., Vol. XI, p. 222.

[6] Records, G. S. I., Vol. XVI, p. 203.

Series II.—Elements generally electro-negative.

2. Sulphur group.[1]

Sulphur.—Native sulphur has been found in various localities, in some of which the deposits are of considerable extent (Pt. III, p. 155).

Since the issue of Mr. Ball's work the sulphur of Barren island, in the Bay of Bengal, has been re-examined, the conclusion arrived at being, as held by previous visitors, that the quantity is very limited. Both in, and near, the crater of the central cone, and at a point about 250 feet lower down, where a recent lava stream has broken out, crusts varying from 2 or 3 to 6 or 8 inches, or even a foot, in thickness, were found. But the total amount was estimated not to exceed a few dozen tons, and there is reason to believe that the deposition of the mineral has taken place very slowly during the last quarter of a century at least. A sample yielded on analysis :—

Sulphur	88·92
Water	2·44
Fixed residue ($CaSO_4$, ash, &c.)	8·64
	100·00

From some of the crevices of the lava, well-formed aggregated crystals of sulphur, in unmodified rhombic octahedrons (P.), were obtained.[2]

A sulphurous earth from the Godávari district, perhaps the same substance as that described by Dr. Heyne in 1814,[3] has been recently analysed by Dr. C. J. McNally, chemical examiner, Madras, with the following result :—

Free sulphur	28·32
Combined sulphur	·28
Sand	43·05
Moisture	17·20
Organic matter	7·30
Potash	·58
Iron, &c., not estimated	3·27
	100·00

At Khátan, in North-Eastern Beluchistán, "are several copious springs of sulphurous waters, which have a temperature of 109° F. at the point

[1] No representatives of the 1st, or arsenic, group have as yet been found in India.

[2] F. R. Mallet : Memoirs, G. S. I., Vol. XXI, pp. 268, 270, 278.

[3] Tracts, historical and statistical, on India, p. 186; Pt. III, p. 156.

of overflow; considerable quantities of sulphur crystals occur in the stalagmite surrounding them. * * * Further up the hillside are many places where similar springs have accumulated stalagmite, with sulphur intermingled in past time."[1]

3. Carbon-Silicon group.

Diamond.—The subject of Indian diamond, and the various localities where the mineral is found, has been very fully treated by Mr. Ball (Pt. III, p. 1).[2]

In some mineralogical and other works it is said that, while Brazilian diamonds are mostly rhombic dodecahedrons, those from India are chiefly octahedrons, a statement which is not borne out by the specimens in the Geological Survey Museum. These include—

From the Karnul district.—Five crystals, four of which are tetrakishexahedrons, and the remaining one a combination of the octahedron and rhombic dodecahedron.

From Sambalpur.—One crystal; combination of tetrakishexahedron and octahedron.

From Panna.—Four crystals, all of which are distorted tetrakishexahedrons.

Said to be from near Simla.—Four crystals: *a*, distorted tetrakishexahedron; *b*, ditto with octahedron; *c*, *d*, octahedron with tetrakishexahedron.

All the tetrakishexahedrons have curved faces.

Thus, out of 14 crystals there are—

Tetrakishexahedrons	9
Tetrakishexahedrons with octahedron	2
Octahedrons with tetrakishexahedron	2
Octahedron with dodecahedron	1
	14

or 11 have the tetrakishexahedron as the predominant form, and 3 the octahedron; of the latter, 2 are of doubtful locality.

The number of crystals is altogether too small to found any generalization upon, but it is sufficient to suggest the enquiry on what authority the statement alluded to has been made.

As large diamonds are rarely found in India nowadays, allusion may be made here to one discovered, about the year 1881, near Wajra

[1] R. A. Townsend: Records, G. S. I., Vol. XIX, p. 208.

[2] Some remarks on the diamond gravels of the Kistna, and on recent experimental diggings at Wajra Karur, in Bellary, by Mr. R B. Foote, may be found in Records, G. S. I., Vol. XVIII (1885), p. 24; and Vol. XIX, p. 109.

Karur, in the Bellary district. It was eventually bought by Messrs. P. Orr & Sons, of Madras, by whom models of the gem, before and after cutting, were presented to the museum. The uncut diamond, judging from the model, was of irregular shape, without determinate crystalline form. In the rough it weighed $67\frac{3}{8}$ carats, and it was cut into an exceptionally fine brilliant, of the purest water, weighing $24\frac{5}{8}$ carats, which has been called "the Gor-do-Norr." [1]

Graphite.—The localities where graphite has perhaps been found most abundantly in India are in the Madras presidency, especially in Travancore, where the mineral is of better quality than elsewhere, although still inferior to that worked so extensively in Ceylon. It also occurs in several parts of the Himalayas, although in a very impure form; and in some other parts of India (Pt. III, p. 50).

In 1882 a sample of graphite of fairly good quality, for a surface piece, was sent to the museum by the commissioner of the Chhattisgarh division (Central Provinces), who stated that similar stuff was "said to occur in large quantities near the villages of Lanjigaon and Dingsargi in the feudatory state of Kalahandi" (Chhattisgarh).

According to Mr. W. Theobald, "Colonel Bogle forwarded specimens of graphite of fair quality from the Tenasserim provinces, and Dr. Mason records having seen fine specimens from the Kannee valley, 20 miles north-east of Toung-ngoo, where the Karens report the substance abundant." [2]

A peculiar carbonaceous mineral was discovered by Dr. Emil Stœhr in the Jamjura copper mine, Singhbhum, 37 feet below the surface. It occurred, in the neighbourhood of a fault, in loose pieces in the cavities of friable quartzose veinstone and copper ore (a specimen now in the museum thus partially occupies a cavity in a mixture of quartz and malachite). Bergrath Breithaupt at Freiberg, to whom specimens of the substance were sent, gave the principal characters as follows: black; semi-metallic lustre on fresh fracture; black streak; opaque; thick pieces of the size of an egg and under; internally crystalline, very fine-grained; sp. gr. 1·92; hardness $4\frac{1}{2}$ to $4\frac{3}{4}$ (some specimens according to Dr. Stœhr have a hardness less than 4); brittle; very difficult to burn before the blowpipe. The mean of analyses by Scheerer and Rube gave—

Carbon	93·945
Water	1·440
Acid	2·895
Ash	1·720
	100·000

[1] A kind of parody on "Koh-i-noor," based on the name of the senior partner of the firm, Mr. Gordon Orr.

[2] The Natural Productions of Burma, 2nd edition (1882), edited by W. Theobald, p. 10.

The substance was considered by Breithaupt as intermediate between anthracite and graphite. Dr. Stœhr mentions that he possessed a piece of veinstone which, together with the mineral in question, contained undoubted flakes of graphite. The cavities in which the substance was found were angular, as if due to the removal of some crystallized mineral; and Professor Kengott supposed that some "highly carbonaceous silicious mineral" had decomposed, the silica being removed while the carbon was left behind.[1]

Under the name of "Tremenheerite" Mr. Piddington described a carbonaceous substance sent from Tenasserim by Captain Tremenheere.

"It is, when fresh, in masses of a scaly structure and of a deep black colour, with a highly metallic lustre, much resembling coarsely-foliated graphite; after a few months it partly falls to powder, or rather into scaly flakes, evidently from the decomposition of pyrites, of which it contains about 3 per cent. It powders easily, but the powder is always scaly, soiling, greasy, and glittering, like graphite. * * * It soils much, but is too soft to mark with, nor can any very determined streak be made; what is so is of a deep black."

Analysis gave—

Carbon	85·70
Water and sulphur	4·00
Peroxide of iron	2·50
Earth, chiefly silica	7·50
	99·70
Water and loss	·30
	100·00

The mineral "differs from the anthracites in its high lustre, scaly structure, and ready pulverisation, by which it approaches the graphites; as well as by its iron and very slow combustion; but then from these it differs by its streak, and high combustibility with nitre; for, like coal and the anthracites, when projected upon melted nitre it deflagrates, heating the crucible instantly to redness, while the graphites not only boil but heat the crucible also, and seem but partly, and very slowly, to part with their carbon till a much higher heat is given. This distinction I have not yet found noticed in any chemical or mineralogical work, but it seems to me to be no bad test by which to separate the graphites from the anthracites; namely, that with nitre, at a heat a little above its melting point only, the former melt and are consumed, while the latter deflagrate and almost explode."[2]

[1] Vierteljahrsschrift der Naturforschenden Gesellschaft, in Zurich, Vol. V (1860), p. 347; Records, G. S. I. Vol. III, p. 91.

[2] Jour. As. Soc., Bengal, Vol. XVI (1847), Pt. 1, p. 369.

Captain Tremenheere's specimens[1] were obtained from the Thuggoo and Therabuen (two streams which flow into the great Tenasserim river), where the substance was abundant. Dr. T. Oldham has recorded that at "Bankyop, Tagoo creek,[2] Banpyai, and Mauton, on the great Tenasserim river, and in Tagit creek on the Little Tenasserim, no coal exists; a black carbonaceous rock, with quartz nodules, which crumbles into powder on exposure and soils the fingers, having been mistaken for coal."[3] This carbonaceous rock is evidently the same as Mr. Piddington's Tremenheerite. All the localities mentioned by Captain Tremenheere and Dr. Oldham (except perhaps Banpyai, which is not marked on the map) are within 15 miles of Tenasserim town. Unfortunately we possess no accurate information as to the rocks in that neighbourhood, whether metamorphic or not—an important point with reference to the nature of the substance in question. Dr. Oldham, however, states distinctly that it is not coal. Professor Dana suggests that it may be "impure graphite, or is between coal and graphite."[4] As graphite and anthracite both deflagrate with nitre, a diagnosis founded only on difference of temperature at which the deflagration takes place, scarcely seems a very safe one. The present writer found that admixture of pyrites has a marked effect in lowering the deflagrating point for graphite, and the pyrites in the 'Tremenheerite' could scarcely have been without influence in this way. There are no specimens of the substance in the Museum, so that there are no means for re-examining it at present.

Dr. F. Mason says that Tremenheerite "appears to be an abundant mineral in the provinces, there being several localities where it is found in the vicinity of both Tavoy and Maulmain;" and he mentions one or two spots where it had been found in connection with "sandstone and slate or shale."[5] But it is perhaps not altogether certain that what Dr. Mason called Tremenheerite is identical with the substance described by Mr. Piddington.

[1] Erroneously described by him as *wad*. *Vide* Selec. Rec., Bengal Govt., VI, p. 12; Jour. As. Soc., Bengal, Vol. X, p. 852; and XVI, Pt. I, p. 369.

[2] Doubtless Captain Tremenheere's "Thuggoo."

[3] Select. Rec., Government of India, No. X, p. 37.

[4] System of Mineralogy, p. 25.

[5] The Natural Productions of Burma, p. 54.

II.—Sulphides, Arsenides, Antimonides.

1.—Binary Compounds—Sulphides of Metals of the Sulphur and Arsenic groups.

Realgar.—A specimen of orpiment said to be from Munsiári, in Kumaon, which includes some realgar, and also a lump of pure massive compact realgar, weighing over a pound, said to be from the same place, are included in the museum collections.

A specimen of orpiment, mixed with some realgar, from the hills north-west of Killa Drassan, in Chitrál, north-west of Káshmir, has lately been presented by Dr. Giles, Naturalist to the Gilghit Mission.[1]

Dr. Mason says that "realgar is found in great quantities in Burma, and is constantly seen in the bazars,"[2] but this statement, if meaning that the substance occurs naturally there, requires confirmation (*vide* "orpiment").

Orpiment is found near Munsiári in Kumaon, according to Mr. A. W. Lawder.[3] There is a specimen in the museum presented by him, and said to be from that locality.

The same mineral occurs in Chitrál, as just noticed under realgar. The writer has been informed, by Dr. Giles, that he saw forty or fifty sacksful in the Chitrál bazar, where it is sold at two rupees a maund, and that the substance is a regular article of trade to Pesháwar.

Dr. Mason states that orpiment is imported from Upper into Lower Burma, but it is open to question whether either this mineral or realgar occurs there naturally. Mr. Theobald omits them in his revised edition of Dr. Mason's work, and Dr. J. Anderson mentions that orpiment is brought in considerable quantities every year from the neighbourhood of Talifoo, in the Chinese province of Yunan, to Yungchan and Momien, for exportation to Burma.[4]

Stibnite has been reported from numerous places in India, in some of which it is said to occur abundantly. The lodes at Shigri in Lahol (North-West Himalayas) are described as of extraordinary richness, one "of solid ore," being from 10 to 15 feet wide[5] (Pt. III, p. 163).

[1] Records, G. S. I., Vol. XIX, p. 270.

[2] Natural Productions of Burma, p. 51. The author evidently means Upper Burma in the passage quoted.

[3] Records, G. S. I., Vol. II, p. 88.

[4] Expedition to Western Yunan, pp. 92, 328.

[5] Kulu: its beauties, &c., by J. Calvert, p. 49.

Stibnite "appears to be pretty general throughout the Tenasserim provinces, accompanying the sandstone of the older formation, in which it is found forming veins of various dimensions, which ramify in all directions from the principal vein. Several localities in the sandstone range of hills enclosed by the Attaran and Maulmain rivers have been worked. * * * Specimens of this ore have been brought from several sites on the small creeks of the Gyne, Haundrau, and Zimmee rivers."[1]

Some of the deposits in the Amherst district (Tenasserim) have lately been described by Mr. W. R. Criper. At Toungwayn, near Maulmain, "the stibnite occurs in pockets, or isolated masses, in a whitish quartzose sandstone, the rock in the immediate neighbourhood being often stained of a bluish colour by the antimony itself. The deposits are generally found in, or by the side of, dykes, or rather fissures, traversing the sandstone, filled with a whitish quartzose rock, and usually having well-defined walls." The sulphide is altered near the surface into cervantite. At Tæ-læ-dwin, at the 23rd mile from Maulmain on the Amherst road, another mine, or rather quarry, was opened, measuring about 50′ × 12′ × 12′. "The deposit is divided by well-defined walls from the ordinary yellow sandstone surrounding it. The ore in these deposits dies out entirely, and no lode, or even string, is left to show in what direction more may be found. Sandstone surrounds it on all sides, and the only chance of any indication lies in the occurrence of an outcrop along, or near, the line of dyke or fissure. From a single deposit a few tons only of ore is obtained. The richest ore is in the centre, and may contain as much as 70 per cent. of antimony (metal), and from this it graduates off into a blue slaty stone containing two or three per cent. only of the metal."[2]

Bismuthinite.—"Sulphuret of bismuth occurs with the ore of antimony in the sandstone range of hills," enclosed by the Attaran and Maulmain rivers, in Tenasserim, but it is not known whether the mineral exists in any quantity.[3]

Molybdenite.—Fairly good individual specimens—plates up to an inch across—have been found in the Patru river near Máhabágh, with galena, copper pyrites, bornite and blende, in a matrix of coccolite and garnet, but the mineral is very rare.[4]

A few plates have also been observed in the Báraganda copper mine, where it occurs with copper and iron pyrites, and a little blende, in

[1] E. O'Riley: Jour. of the Indian Archipelago, Vol. III, p. 733.

[2] Records, G. S. I., Vol. XVIII (1885), p. 152. Mr. H. B. Medlicott (*l.c.*) suggests a doubt whether the matrix may not be a partially disintegrated metamorphic rock.

[3] E. O'Riley: Jour. of the Indian Archipelago, Vol. III, p. 737.

[4] The locality is described in Records, G. S. I., Vol. VII, p. 34, but the molybdenite was discovered subsequently, during some unsuccessful mining operations.

chloritic and micaceous schist. At Umri, near Dumri, on the Damunia river, Mr. F. Fedden obtained a few scales of the same substance. There are specimens in the Museum from the above localities, which are all in the Hazáribágh district, Bengal.

The same mineral is said by Mr. Ball to occur in the metamorphic rocks of Mánbhum.[1]

According to Dr. Balfour, Captain Campbell "discovered an iron (?) ore resembling sulphuret of molybdena about four hundred yards from Bombay House" in the Nilgiris.[2]

2.—Binary Compounds—Sulphides and Arsenides of Metals of Series I.[3]

A. Basic Division.

O'Rileyite.—This name was given, by Dr. D. Waldie, to a substance of which two samples were sent to him for examination in 1863 by Mr. O'Riley, Deputy Commissioner of Martaban. Dr. Waldie received no definite information as to the locality whence they were brought, but in a letter to the Commissioner of Tenasserim[4] Mr. O'Riley says, "The site of this deposit is said to be on the Yoonzalem river, and accessible by boats."

The second sample is described as having "an uneven fracture of a laminated structure, somewhat cellular, of a steel-gray colour, with a purplish tint and metallic lustre. In general appearance it is like mispickel, but of a redder shade." Hardness = 5·5, streak dark gray; specific gravity of small pieces at 81° F. = 7·343, of the powder 7·428. The first sample was similar in appearance. On analysis they respectively gave—

Copper	17·000	12·13	Insoluble in dilute HCl.
Silver	·096	...	
Iron	36·470	42·12	
Arsenic	32·700	38·45	
Antimony	1·150	·54	
Sulphur	1·360	...	
Oxide of copper	...	1·21	Soluble in dilute HCl.
Protoxide of iron	...	1·97	
Oxide of lead	...	1·89	
Arsenious acid	...	1·12	
Earthy matter	·560	·12	
Loss	10·624	·45	
	100·000	100·00	

[1] Memoirs, G. S. I., Vol. XVIII, p. 103.
[2] The Iron Ores, &c., of the Madras Presidency (1855), p. 182.
[3] Or Gold, Iron, and Tin groups.
[4] Dated 6th December 1864.

The loss in the first analysis was thought to be mainly due to arsenic volatilised as chloride.[1]

Taking the new atomic weights, the figures given in Dr. Waldie's second analysis afford the atomic proportion (As Sb) : (Cu_2 Fe) : 2 : 3·28, giving an approximation to the formula $(Cu_2 Fe)_3 As_2$, or, more generally, $(Cu_2 Fe)_3 (As Sb)_2$. According to this result, O'Rileyite is more nearly allied to domeykite than to any other known mineral, the latter, $(Cu_2)_3 As_2$, being an arsenide of copper alone, while in O'Rileyite the copper is largely replaced by iron.

According to Dr. Helfer, "to the south of the island of Madramee" (Tenasserim), "veins of an iron ore occur, whose constituents are, besides iron, copper, lead, and arsenic."[2] Is this O'Rileyite or something allied thereto?

B. Proto Division—General formula RS (or R'_2S), RAs.

Galena, in greater or less quantity, is a widely-distributed mineral. Galena being in India, as elsewhere, almost synonymous with 'lead ore,' Mr. Ball's chapter on Lead (Pt. III, p. 281) gives an abstract of the information available up to 1881. In his chapter on Silver may be found assays of about ninety samples of Indian galena, giving the number of ounces of the precious metal per ton of lead.

The mineral has been found at the following localities in Tenasserim, according to Mr. E. O'Riley:—

1. In the Paguh range of limestone hills which occur between the Yen-bani and Thoung-yeen rivers, having a course parallel to that of the Salween river.
2. In the limestone ranges situated between the Hloni Bwai and the Salween.
3. On the Zemmee river, in the cavernous limestone near its source.
4. At the head waters of the Toung-Byouk stream, which pierces the upraised limestone beds.

The ore has been found in cubic and octahedral crystals, and in lamellar, granular, and compact masses. The analysis of a specimen of "a compact steel-grained variety," of specific gravity 7·2, from the Paguh range, is said to have shown—

Lead	80·24
Silver	4·12
Sulphur	14·06
	98·42

[1] Proceedings, As. Soc., Bengal, 1870, p. 279.

[2] The Provinces of Ye, Tavoy, and Mergui, p. 29.

If the analysis be correct, the specimen was a very remarkable one from the extraordinarily high percentage of silver, but as on the same page Mr. O'Riley speculates on the discovery "perhaps" of a galena containing "a percentage of silver which would amply repay an investment of capital therein,"[1] one cannot but suspect that there may be some mistake. In a subsequent communication Mr. O'Riley states that galena had been obtained from ten different localities in the Martaban district.[2] A sample from one of these, analysed by Dr. D. Waldie, yielded :—

Lead	85·22
Sulphur	13·11
Silver, antimony sulphide, earthy matter, and loss . .	1·67
	100·00

the silver being equal to 5 oz. 14 dwt. per ton of ore.

Samples from the Thandiani range, in the Abbottabad tahsil of the Hazára district, and from the Zidig kotal, in Káfiristán, have been lately sent to the museum. The lead reduced from the former of these was found to contain 15 oz. 1 dwt. of silver to the ton, and that from the latter 28 oz. 5 dwt.

Bornite.—Some good specimens of this mineral, from Bairuki, 9 miles north-west of Deoghar in the Santhál pargannahs, were presented to the museum some time ago by the Deoghar mining company. The mode of occurrence is described under chalcopyrite (p. 25). The mineral has also been found in small quantity, with chalcopyrite, galena, blende, and molybdenite, in a matrix of coccolite and garnet, in the Patru river, near Máhabágh, in the adjoining district of Hazáribágh.

Several writers mention bornite amongst the ores found in the copper mines of Kumaon and Garhwál, where it is associated with chalcocite, tetrahedrite, and chalcopyrite, the last mentioned being the main ore.[3] On crossing from the Moosye range to the mountains of Baghye, in Northern Afghánistán, Captain Drummond obtained some rich specimens of bornite in different places, and at Kila Ataye observed several quartzose veins carrying the same mineral, which was also noticed in smaller quantity in one or two other places.[4]

Jaipurite.—In most standard works on mineralogy some reference is to be found to "syepoorite," a sulphide of cobalt stated, on the authority of Mr. J. Middleton, to occur "in the independent state of Syepoore," in Rájputána. No mineral of the same composition has been

[1] Journal of the Indian Archipelago, Vol. III, p. 736.

[2] Letter to the Commissioner of Tenasserim, dated 6th December 1864. See also map in Records, G. S. I., Vol. VI, p. 94.

[3] The literature relating to these mines is rather extensive,—*vide* Pt. III, pp. 267, 613.

[4] Journal of the Asiatic Society, Bengal, Vol. X, p. 74.

discovered in any other part of the world, and Mr. Middleton's results have not been corroborated by later investigations. His description is as follows :—

"The mineral possessing greatest interest amongst those above enumerated[1] is the sulphuret of cobalt. It is found in the copper mines in considerable abundance and exists in a primitive schist in the form of bands and disseminated grains, the colour of which is a steel gray inclining to yellow. The grains appear to be crystallized, and are probably the cube and its derivatives. * * * By very careful and repeated analysis the reduction process having been adopted for the metal, I found the proportion of the constituents to be, taking the average—

Cobalt	64·64 per cent.
Sulphur	35·36 „

from which it is obvious that the substance is a sub-sulphuret, that its constitution is Co_2S, a rather remarkable result, considering that the iron compound, doubtless of simultaneous formation, is different.[2] The cobalt pyrites has a specific gravity of 5·45. It is used by Indian jewellers for staining gold of a delicate rose-red colour. The *modus operandi* which they follow I have been unable to learn; it is a secret with them, which they are unwilling to disclose."[3]

The name 'syepoorite' appears to have been given by Nicol, who in his manual of mineralogy (1849) says: "This name may be given to a sulphuret of cobalt, probably a distinct species, found in primary rocks with pyrite and chalcopyrite at Syepoore, near Rájputána." Nicol also substituted the formula CoS for Co_2S, as given by Middleton. Whether the old or the new atomic weights be adopted, the figures in Middleton's analysis closely correspond to the formula CoS. It was subsequently pointed out by Major W. A. Ross[4] that "Syepoore *near* Rájputána" should read 'Jeypoor *in* Rájputána.' The name is spelled 'Syepoore' in Middleton's original paper, the S being probably a mere typographical error. In the official Gazetteer of Rájputána the name of the state in question is spelled 'Jaipur,' and hence the name of the mineral should be spelled 'jaipurite.'

An ore of cobalt has long been worked at the Khetri copper mines in Jaipur, and sold to the Indian enamellers, &c., under the name of 'sehta.' The sehta, which is produced by pounding the slaty cobaltiferous rock, and washing away the siliceous matter, has been compared to "a fine gray sand having the appearance of iron filings." It consists of a cobaltiferous mineral, in minute crystals belonging to the isometric system, mixed with copper and iron pyrites, &c. Cobalt is not known to have been found in any other part of Jaipur, or indeed of Rájputána, and it appears, therefore, practically certain that the mineral analysed by

[1] "Sulphuret of copper, sulphate of copper, sulphuret of cobalt, alum."

[2] *Vide* "Pyrrhotite," p. 22.

[3] Memoirs and Proceedings of the Chemical Society, Vol. III, p. 39; republished in the Philosophical Magazine, Vol. XXVIII (1846), p. 352.

[4] Proceedings of the Royal Society, Vol. XXI, p. 292.

Middleton was contained in the sehta just mentioned. Since then three distinct samples of sehta have been examined, one by Major Ross [1] and two by the present writer,[2] and in none of them has any simple sulphide of cobalt been detected. The isometric crystals, which formed the main constituent, Major Ross found, by a blowpipe analysis, to contain arsenic and antimony in addition to sulphur and cobalt. The similar crystals examined by the writer were subjected to quantitative analysis and blowpipe determination, and found to be cobaltite.[3] These results cannot be taken as disproving the accuracy of Mr. Middleton's analysis, as there *may be* two distinct isometric minerals found apart in different portions of the mines, but they are certainly suggestive of doubt. In this connection it may be noticed that Middleton records having obtained some unexpected reactions during his analysis which he does not fully explain, and that if his results be accepted in their entirety, a *second* new mineral peculiar to the Khetri mines, and having some very remarkable properties, must be recognised.[4]

With reference to Mr. Middleton's statement that the cobalt ore "is used by Indian jewellers for staining gold of a delicate rose-red colour," it is employed by the jewellers of Jaipur for enamelling, in different shades of blue, on gold and silver.[5] But, beyond the statement just quoted, we have no knowledge of its being used in any way for the production of a red tint.

Blende is not known to occur in any part of India in large quantity, although a trifling amount has been observed in several places where the mineral is subordinate to other ores. In addition to the localities noticed by Mr. Ball (Pt. III, p. 312), Bairuki, in the Sánthál parganahs [6] the Belar copper mine in Garhwál,[7] and the Sabáthu lead mine, near Simla, may be mentioned, while recently a specimen has been received from Káshmir, the exact locality of which was not given. Blende containing gold and silver is said to have been found in the Madura district of Madras.[8]

Under the name of 'Newboldite' Mr. H. Piddington has described[9] an apple-green mineral occurring, in small quantity, in a gangue of quartz, barite and gypsum, and in one of what he described as carbonate of iron,

[1] *Ibid.*
[2] Records, G. S. I., Vol. XIV, p. 190.
[3] *Vide* "Cobaltite and Danaite," pp. 27 and 28.
[4] *Vide* "Pyrrhotite," p. 22.
[5] Engineers' Journal (Calcutta), Vol. VI, p. 29. Journal of the Asiatic Society, Bengal, Vol. XXXIII, p. 525.
[6] Page 25.
[7] Select. Records, Government of India, No. VIII, p. 10.
[8] Ainslie's Materia Medica of Hindoostan (1813), pp. 54, 58.
[9] Journal, Asiatic Society, Bengal, Vol. XVI (1847), Pt. 2, p. 1129.

lime, and cerium. It was found by Captain Newbold "between Cummum in Cuddapah and Gograpilly in Kurnool," apparently about 6 miles east of Gazoopilly (Gograpilly?) in some deserted lead mines.[1] The result of Mr. Piddington's analysis led him to regard the mineral as "a new and very remarkable one, which is a double *sulphuret of iron and an earth!*",[2] but the amount separable for examination was, as the author remarks, so small that he was unable to determine what the earth was.

Amongst the collections made over to Government by the Asiatic Society in 1866, the present writer found a small glass tube, labelled 'Earth of Newboldite,' and containing ·26 of a grain of pale fawn-coloured and whitish powder. Of this, ·21 grain was found insoluble in HCl, H_2SO_4, or aqua regia, and from this insoluble portion ·16 grain of silica was obtained after fusion with $K_2CO_3 + Na_2CO_3$. The remainder of the powder consisted, in part at least, of alumina, oxide of iron, and oxide of copper.

There are, in the museum, specimens of ferruginous carbonate of zinc, with barite, hornstone, and a little green blende, from the Kurnool district, which, judging from their close resemblance to certain other specimens in the same collection, and to the ore of the Baswapur-Gazoopilly mines, as described by Captain Newbold, almost certainly came from those mines; that is to say, from the locality from which the 'Newboldite' was obtained. The present writer is inclined to believe that the mineral described as carbonate of cerium, &c., was the carbonate of zinc just mentioned,[3] and in several respects—colour, hardness, specific gravity, and cleavage—Newboldite, as described, agrees with the blende above noticed. It should, however, be added that the former is stated to decrepitate violently when heated, while fragments of the latter tried by the writer only did so slightly. The precipitates recorded as produced by various reagents when added to a solution of Newboldite in acid, agree very fairly with those obtainable with a solution of ferruginous blende.[4] It is true, it is not stated that the precipitate given by potash or ammonia is mainly soluble in an excess of the re-agent; but, on the other hand, there is no statement to the contrary. It may be suggested that the large amount of zinc in blende could not have been overlooked by the author quoted, but in this connection a comparison of the analyses given under tetrahedrite and nepaulite[5] is not without point.

Chalcocite.—At the old copper mines near Garimanipenta, in the

[1] *Ibid.*, Vol. XV, p. 390; and XVI, Pt. 2, p. 1134.
[2] Italics and note of exclamation in original.
[3] *Vide* "Smithsonite."
[4] The blende in question was found to contain iron.
[5] Page 30.

Nellore district, chalcocite is said to occur abundantly, with malachite, "in unbroken veins."[1] There is a specimen in the museum, from this locality, weighing about 6 pounds, which evidently formed part of an irregular vein, 2 or 3 inches thick. With the exception of a little malachite and atacamite, and a few disseminated crystals of magnetite, the mass is solid chalcocite.[2]

In the same collection are specimens of the ore from Birman ghát in the Narsinghpur district (Central Provinces), where it occurs with various oxidized cupreous minerals;[3] Sorai, in the Lalitpur district, North-Western Provinces;[4] Kodada, in Dhálbhum; Jamjura, in Seraikela, Singhbhum; and Bairuki, near Deoghar, in the Sánthál pargannahs.[5] In the last-mentioned locality the chalcocite is subordinate to purple copper.

The ore is one of the most common in the Singhbhum mines, and is considered by M. Stœhr the original one from which the oxidized ores have been derived.[6]

We have a fair specimen from Baxa, in the Bhután duárs, the only place in the Eastern Himalayas from which the mineral seems to have been reported hitherto, the ordinary ore in the mines there being copper pyrites. Various authors mention chalcocite amongst the ores found in the mines of Garhwál, where it has been noticed at Dhunpoore, Pokri, and Al Agur.[7] In the Punjab Exhibition of 1864 a specimen was shown from Rondu, 16 marches beyond Káshmir.[8]

In the Salt range chalcocite has been found in a somewhat unusual form, occurring in nodular concretions, varying in bulk from the size of a millet seed to that of a walnut, disseminated through variegated purple or lavender shales and clays of palæozoic (silurian?) age.[9] Small green patches of silicate and carbonate of copper may also be observed in masses of siliceous sinter which occur in the shales. The chalcocite in some of the nodules is very pure, but frequently it only forms the centre of nodular concretionary masses of gypsum and barite. Very often the sulphide is to a greater or less extent converted into carbonate, only the centre of the nodule remaining unaltered. (Specimens now in the Museum are converted rather largely into cuprite, as well as malachite and chrysocolla, and also

Journal, Asiatic Society, Bengal, Vol. IV, (1835), pp. 577, 578; Journal, Royal Asiatic Society, Vol. VII, p. 150.

[2] Records, G. S. I., Vol. XII, p. 171.

[3] Pt. III, p. 257.

[4] *Vide* p. 29.

[5] Page 25.

[6] Records, G. S. I., Vol. III, p. 88.

[7] Asiatic Researches, Vol. XVIII, Pt. I, p. 242; Select. Records, Government of India, No. VIII, pp. 6, 7; *Ibid.*, No. XVII, p. 62.

[8] Economic Products of the Punjab, by Baden-Powell, Vol. I, p. 10.

[9] Memoirs, G. S. I., Vol. XIV, p. 91.

include a little pyrites.) A pure specimen of the chalcocite analysed by Dr. Fleming yielded—

Copper	75·830
Sulphur	21·000
Sulphuret of lead	3·155
Iron and antimony	a trace
	99·985[1]

Usually, however, the concretions appear to contain a much lower percentage of copper, varying between 12 and 20 per cent. Dr. Fleming was of opinion that the siliceous sinter was deposited by thermal waters permeating the shales, which had also been the vehicle by which the copper sulphide had been introduced, the latter subsequently aggregating into nodules. So complete has been the segregatory action, he remarks, that not a trace of copper can be detected when small portions of the shales are submitted to analysis. Although the cupriferous beds have been traced through a distance of not less than 40 miles, between Bayaar, east of Moosakhail, and Kuttha, the quantity of ore obtainable is very insignificant, and only noticeable from a mineralogical point of view.

Captain Drummond discovered small cupriferous veins containing chalcocite, red oxide, &c., at Tezeen and Dobundee, in Northern Afghánistán.[2] Colonel Brooke speaks of 'black sulphuret' as one of the minerals worked at Khetri, in Rájputána, where it is, however, subordinate to copper pyrites, and amongst the specimens from the mines sent by him to the Asiatic Society 'glance ores' are mentioned.[3]

Cinnabar.—Not known to occur in India. (Pt. III, p. 170.) According to Dr. R. Saunders, "cinnabar, containing a large portion of quicksilver, is found in Tibet," by which, probably, the portion between Eastern Bhután and the Sangpo river, where he travelled, is meant.[4]

[1] This is the analysis as given by Mr. W. Theobald (Jour. As. Soc., Bengal, Vol. XXIII, p. 662), who says it was published in the *Delhi Gazette*, 1850. In Dr. Fleming's own paper, however (*Ibid.*, Vol. XXII, 1853, p. 258), what is evidently the same analysis is given thus :—

Copper	75·830
Sulphur	21·000
Sulphuret of soda	3·155
Peroxide of iron and alluminæ	0·15
	100·000

There being certainly one typographical blunder in the word 'alluminæ,' it is not difficult to believe that *soda* has crept in for *lead*.

[2] Jour. As. Soc., Bengal, Vol. X, p. 77.

[3] *Ibid.*, Vol. XXXIII, pp. 522, 529.

[4] Captain S. Turner's Embassy to Tibet (1800), p. 405.

Pyrrhotite.—Specimens of pyrrhotite, with chalcopyrite, in talcose schist, from Pokri in Garhwál, and of the same two minerals in gray slate from Daribo in Ulwur,[1] are included in the museum collections. According to Captain Dangerfield, magnetic pyrites is common, in chlorite slate, in the Maunpoor or Suloombur range, some 40 miles or more to the south-east of Oodeypore.[2]

Pyrrhotite is found in the Khetri mines, Rájputána, with chalcopyrite, &c., and there is reason to believe that it occurs there in considerable abundance. Specimens in the museum, consisting of pyrrhotite and copper pyrites, disseminated through a slaty gangue, were found to contain a trifling amount of cobalt with a trace of nickel. The latter is very probably a constituent of the pyrrhotite, the cobalt most likely being present as cobaltite in very minute crystals.[3] The pyrrhotite in the above specimens has the ordinary colour and metallic lustre.

In his paper on the mineral since termed jaipurite, which, as already pointed out,[4] was obtained beyond all reasonable doubt from the Khetri mines, Mr. Middleton writes :—

"What is particularly remarkable in this (cobalt) ore is its purity, so far surpassing in this respect any that, so far as I am aware, is to be met with anywhere else. The only substance in combination with it, after separation of the matrix, is an iron pyrites, which is, however, but mechanically mixed, and so highly magnetic as to be readily removeable by the magnet. The relative proportions in which these two exist are—

Cobalt pyrites	90·78 per cent.
Iron	9·22 „

"The iron pyrites consists of black amorphous granules without metallic lustre, and, as above stated, it is highly magnetic, having at the same time the low specific gravity of 2·58. It gives on analysis—

Iron	62·27 per cent.
Sulphur	37·73 „

"The analysis was carefully made, and repeated for verification, so that, notwithstanding the specific gravity is so much lower than that assigned as characteristic of iron pyrites, there can be no doubt such is the constitution of this constituent of the ore in question."[5]

The percentage found by Middleton corresponds to $Fe_{17}S_{18}$, or intermediate between the composition of pyrrhotite, as ordinarily given, and that of troilite, being very near both. But the physical characters of the mineral as given by him are widely different; the colour is black, the lustre non-metallic, and the specific gravity extraordinarily low. Such remarkable results certainly need confirmation.

[1] Page 24.
[2] Malcolm's Central India, Vol. II, p. 340.
[3] Page 27.
[4] Page 17.
[5] Memoirs and Proceedings of the Chemical Society, Vol. III, p. 39; republished in the Philosophical Magazine, Vol. XXVIII (1846), p. 352.

Sulphide of lead and copper (?).—An ore brought by Dr. Heyne from Madras, where it was sold in the shops for medical purposes, but which he thought had probably come originally from Malacca or Sumatra, was examined by Dr. Thomas Thomson, in 1814.[1] As the substance was not impossibly Indian, the result may be introduced here.

External colour blackish-blue. On a fresh fracture the appearance of steel-grained galena, but with a darker colour. Subject to speedy tarnish. Fracture small-grained, uneven. External lustre glimmering and semi-metallic. Internal lustre splendent and metallic. Soft, easily scratched with a knife. Streak lead-blue. Rather sectile. Specific gravity = 6·590.[2]

On analysis Dr. Thomson obtained—

Lead	50·059
Copper	32·500
Iron	1·370
Sulphur	11·328
Loss	4·743
	100·000

He thought that the deficiency was due to sulphur lost during analysis, and found that the percentages of metal obtained were equivalent to—

Sulphuret of lead	57·269	PbS	57·80
Sulphuret of copper	40·850	Cu_2S	40·73
Sulphuret of iron	2·190	FeS	2·15
	100·309		100·68

He therefore considered the substance, which he believed to be a natural product, and a chemical compound of the two principal constituents, not a mixture, to be a sulphide of lead and copper. The sulphide of iron he regarded as accidental, but he gives no reason for this opinion.

In the fourth column above, Dr. Thomson's figures are re-calculated, using more recent atomic weights. Accepting the loss as sulphur, the figures of his analysis afford the atomic ratio S : Cu_2 : Pb : Fe : 2 : 1·026 : ·965 : ·097, giving a close approximation to the formula Cu_2S. (PbFe) S. If the iron be excluded as pyrrhotite or pyrite, the formula will approximate, though not so closely, to Cu_2S. PbS.

It is noticeable that no mention is made of this substance in Dr. Thomson's Mineralogy (1836).

[1] Memoirs of the Wernerian Natural History Society, Vol. II (1818), p. 252.

[2] According to Dr. Heyne, some pieces were of specific gravity as low as 4·9.

C. Deuto Division—General formula RS_2^1, RAs_2.

Pyrite is a widely distributed mineral, occurring in formations of various ages. But nowhere is it known to occur, either in forms of any special mineralogical interest, or in deposits sufficiently extensive to be of much practical importance (Pt. III, p. 418).[1]

Chalcopyrite.—In India, as in so many other parts of the world, chalcopyrite is by far the most abundant ore of copper, and that most commonly met with. It has been mined in various parts of the country, and is known to occur in many others. In Mr. Ball's chapter on Copper (Pt. III, p. 239) will be found a *résumé* of the information published on the subject.

The Daribo mine,[2] in Ulwur, Rájputána, was examined in 1884 by Mr. T. F. Andresen, M.E., who arrived at the conclusion that the deposit "is a true fissure vein, occurring at the junction of the quartzites with the black slates, the copper-bearing stratum being formed between these. The hanging wall consists of quartzite and the foot wall of black slate. The course of the lode is a few points east of south, with an average width of 20 inches; the croppings can be plainly traced for a distance of over half a mile, and the ledge has a varying dip of from 80° to 50°. The mineral is principally copper pyrites. * * * The Chipta copper mines, of which there are two, are situated in a series of rolling hills about four miles from Dariba; they are said to have yielded good ore in large quantities."[3]

The opening out of the old Báraganda mines, in the Hazáribágh district[4] by the Bengal Báraganda copper company, has afforded an opportunity for examining the deposits there under much more favourable circumstances than before. When visited by the writer in January 1885, the workings had attained a depth of 174 feet and were well below the old native pits. As in so many other parts of India, the copper ore does not occur in a lode, but as a constituent of schistose strata. The cupriferous rock is mainly chloritic and micaceous schist, of which the ore forms an integral part. The latter is copper pyrites, occurring in lenticular masses, which are generally from a sixteenth of an inch, or less, in thickness, up to a quarter of an inch, or more. Occasionally they exceed an inch, and exceptional specimens of solid ore have been obtained three or four inches thick. The chloritic or micaceous consti-

[1] For pyrite lately discovered in the Andaman Islands, which is, however, no exception to the general rule, *vide* Records, G. S. I., Vol. XVII, p. 80.

[2] Records, G. S. I., Vol. X, p. 91.

[3] Mining Journal, 30th August 1884, p. 1029.

[4] Pt. III, p. 254.

tuent laps round the cupreous, so that when lumps of the rock are looked at on faces parallel to the foliation, little or no ore is visible, although in the best samples a large proportion of copper pyrites can be seen on fractures across the line of foliation. Associated with the copper ore there is more or less iron pyrites, and occasionally a little blende. Garnet is not unfrequently present in small dodecahedral crystals. Translucent quartz, containing more or less ore, occurs through the schist in lenticular layers of every thickness from a small fraction of an inch to more than a foot. The layers are sometimes so strangulated as to approach a globular form. The foliation of the schist, on the large scale, is, like that of the adjacent country rock, or barren schist, vertical, or very nearly so. The cupriferous band, as exposed in the workings, varies considerably in thickness, from about 20 to 40 feet. The distribution of ore is very unequal. Some portions of the rock are very poor, others comparatively rich. A carefully-selected average sample from a heap of some 250 tons of the richer class of ore, undressed, as it came from the mine, was found by the writer to contain 3·04 per cent. of copper, equal to 8·79 per cent. of copper pyrites.

The Deoghar mining company's property at Bairuki, in the Sánthál pargannahs,[1] has also been examined by the writer. The mine is situated some 300 yards east of the East Indian Railway, about 5 miles north of Baidyanáth station. The 'country rock' on either side of the ore-bearing stratum is a rather fine-grained, well-foliated gneiss, composed of translucent quartz, white felspar, and black or dark-coloured mica. The rock is highly garnetiferous in some places. The metalliferous stratum is a white tremolite schist, which varies greatly in thickness in different parts of the mine. In some places it is as much as six or eight feet; in others it is but one or two; or, again, dwindles to a few inches. There are spots, too, where it is entirely absent. This irregularity is probably due, in large part, to original variations in the thickness of the stratum, but partly to subsequent compression. Very clear sections are obtainable, in the levels and cross-cuts, of the gneiss on either side. Although there is generally a well-marked plane of demarcation between the two rocks (and consequently well-marked hanging and foot wall to the ore-band), the foliation of one rock is quite conformable to that of the other, and it seems clear that the ore-band is a portion of the metamorphic schists themselves, and not a true lode. As far as the writer is aware, indeed, tremolite has not been observed as a true veinstone.

The general strike of the ore-band, and of the gneiss on either side, is about E.—W., with a high dip to the south, which averages perhaps 70°.

The copper ore is chiefly of two kinds; copper pyrites, which occurs

[1] Pt. III, p. 244.

in small, irregular, lenticular masses lying parallel to the foliation of the schist, and to all appearance forming (like the ore at Báraganda) an original constituent of the schist itself; and purple copper, which occurs partly in the same way as the above, but partly in small strings more or less transverse to the foliation. The ore found in the lower part of the mine (the 150-feet level and below) is mainly of the first kind; that in the upper part (80-feet level, &c.) is mainly of the second. It may be that the purple copper is due to alteration of the other, and that the cross strings have been produced during the process.

Besides the chief ores there is a little chalcocite, but it is very rare; also black copper and green carbonate, &c., in small quantity. Some blende and galena have been found, the former chiefly with the yellow ore, and there is some iron pyrites present likewise.

The amount of ore which has been obtained is quite trifling in comparison with the amount of work that has been done, not exceeding a few tons. Some good ore was orginally found at the surface (which led to the mining adventure being undertaken); and two or three productive pockets were met with at certain parts of the workings; but elsewhere the ore-bearing stratum is very poor.

The metal-bearing stratum does not admit of being traced east or west of the mine by any surface indications, other than the general strike of the gneiss. There is no gossan, or other indication of ore, and the writer observed no outcrop of the tremolite schist.

Some large lumps of galena were obtained, at or near the surface, from a spot about 150 yards S.S.-W. of the mine, and the rocks there show some green strains of copper. A pit was sunk, but no further ore was obtained in it.

Chalcopyrite, occurring with iron pyrites and hematite in irregular strangulated veins, and also with the same minerals in what appears to be a true lode, with chloritic quartzose gangue, was discovered near Port Blair, in the Andaman islands, by Mr. M. V. Portman in 1883. The ores occur in connection with altered and eruptive rocks, but are not likely to prove of any practical value.[1] The same sulphides have also been found, under very similar circumstances, at Kamorta, in the Nicobar islands.[2]

A peculiar specimen of copper pyrites, from the Mangphu mine, in the Dārjiling district, may be noticed here. It was sent for examination by Mr. A. O. Hume in 1873, and was described by Mr. Tween, late chemist to the Geological Survey, as "very hard to scratch and much resembling iron pyrites." The resemblance in colour to the latter

[1] Records, G. S. I., Vol. XVII, p. 80.

[2] H. Rink, Selec. Records, Government of India, No. LXXVII, p. 133.

mineral was also noticed by the writer. Notwithstanding the paleness of tint, Mr. Tween's analysis gave—

Copper	28·8	34·6
Iron	25·5	30·6
Sulphur	29·0	34·8
Quartz	16·7	...
	100·0	100·0

—a result which, excluding the quartz, coincides almost exactly with the theoretical composition of chalcopyrite. The unusual hardness and pale colour were doubtless due to the disseminated quartz. The ore commonly found in the mine is copper pyrites of the ordinary shade.[1]

Cobaltite occurs in minute crystals, disseminated through dark-gray slate, in some of the Khetri mines in Rájputána, especially those at Babai and Bagor, two villages respectively 8 and 2 miles south of Khetri. Associated with it are copper and iron pyrites and danaite. The crystals, almost without exception, are combinations of the cube, pentagonal dodecahedron $\left(\frac{\infty O 2}{2}\right)$ and octahedron, with the cube as the predominant form (fig. 1);[2] in a very few the octahedron predominates. The largest crystals are only about the fiftieth of an inch in diameter. Specific gravity = 6·00. The mineral yielded on analysis[3] —

Sulphur	19·46
Arsenic	43·87
Antimony	trace.
Cobalt	28·30
Nickel	trace.
Iron	7·83
Gangue	·80
	100·26

Under the name of 'sehta' the mineral is used by Indian jewellers for producing a blue enamel.[4] According to Colonel J. C. Brooke (writing some years ago), not more than 200lb per month was obtained from any one mine.[5]

[1] Memoirs, G. S. I., Vol. XI, p. 76.

[2] Major W. A. Ross has described a cobaltic mineral from the same mines, occurring in similar minute crystals showing identically the same combination of faces. As his quantitative analysis, showing cobalt, antimony, arsenic, and sulphur, was made with the blowpipe only, and the percentage of some of the constituents was merely guessed at, one cannot but strongly suspect the mineral to have been cobaltite. Major Ross himself says that his results are merely given "temporarily, until a sufficient quantity of the *pure* mineral (not the sand) be obtained to submit it to a regular chemical analysis."—(Proceedings, Royal Society, Vol. XXI, p. 292; Records, G. S. I., Vol. XIV, p. 192.)

[3] F. R. Mallet: Records, G. S. I., Vol. XIV, p. 190.

[4] *Vide* jaipurite, p. 16.

[5] Jour. As. Soc., Bengal, Vol. XXXIII, p. 524.

Marcasite.—Although there can be little doubt that this mineral exists in many parts of India, only one notice of its occurrence has been met with by the writer, "prismatic iron pyrites" being said to be "accompanying the upper stratum of the coal to the southward of Mergui." [1]

Leucopyrite.—A mass of leucopyrite, weighing about three quarters of a pound, was found embedded in the coarse granite of a dyke crossing the Sakri river, above Sánhk, in Northern Hazáribágh.[2]

Arsenopyrite.—On the western flank of Sampthar hill, in the Dárjiling district, about half a mile W. 20° S. from the highest summit, there is a seam about a foot thick, of which perhaps two thirds is arsenical pyrites (probably arsenopyrite), mixed with iron and copper pyrites. The remainder of the seam is rusty quartzose schist, which divides the ore into two layers.[3]

According to Dr. Mason, "arsenical sulphuret of iron" occurs in some parts of Tenasserim, but no localities are given.[4]

"Arsenical pyrites," which may or may not be arsenopyrite, has been found at Uchich, near Manikarn, in Kulu;[5] and at the Daribo copper mine, in Ulwur, Rájputána.[6]

Danaite, or cobaltic arsenopyrite, occurs in minute crystals, disseminated through dark-gray slate, in some of the Khetri mines, in Rájputána. Associated with it are cobaltite (*q. v.*), copper- and iron-pyrites. Perhaps the commonest combination shown by the crystals is $\infty P . P \infty . \frac{1}{2}P\infty$, with sometimes the faces $\overline{P}\infty$.[7]

3.—Ternary Compounds—Sulphantimonites, Sulpharsenites.

Bournonite is said to have been obtained near Maulmain.[8] According to Mr. Atkinson, "in digging the foundations of a house at Háwalbágh, in Kumaun, the workmen came on a vessel containing three crystallized specimens of bournonite, the only trace hitherto discovered of its existence in these hills (1826)." [9]

[1] The Provinces of Ye, Tavoy, and Mergui, by J. W. Helfer (1839), p. 29.
[2] Records, G. S. I., Vol. VII, p. 43.
[3] Records, G. S. I., Vol. XV, p. 57.
[4] The Natural Productions of Burma, p. 40.
[5] Kulu: its beauties, &c., by J. Calvert, p. 62; Memoirs, G. S. I., Vol. V, p. 166.
[6] C. A. Hacket: Records, G. S. I., Vol. X, p. 91.
[7] Records, G. S. I., Vol. XIV, p. 195.
[8] Burma, &c., edited by W. Theobald, p. 11.
[9] Economic Mineralogy of the Hill Districts, North-Western Provinces, p. 23.

Tetrahedrite.—Some loose pieces of quartzose cupriferous veinstone, containing tetrahedrite with native copper, cuprite, and malachite, were found, by Mr. H. F. Blanford, in a stream south of Vèppur in the northern part of the Trichinopoly district.[1]

Gray copper is said by Mr. C. Durrschmidt to be one of the chief ores in the Singhbhum mines,[2] but Mr. Stœhr states that the original (unaltered) ore is chalcocite, and does not mention gray copper.[3] The former statement must be looked upon as highly dubious, especially as Mr. Durrschmidt defines fahlerz as "gray sulphuret of copper and iron."

The ore from Bairuki, in the Sánthal pargannahs, called fahlerz by Mr. Piddington, was probably a mixture of chalcocite, or bornite, and galena. The author quoted expressly states that "it contains no trace of antimony."[4]

Tetrahedrite has been found by Mr. Olpherts in small quantity, in a barite matrix, near Sleemanabad railway station, in the Jabalpur district.

Copper ore has been obtained, although the mode of its occurrence is rather obscure, at Sorai (or Saunrai) near Maraura, in the Lalitpur district, North-West-Provinces. The place is said to have formerly yielded large supplies, and there is some reason to suppose that the ore was gray copper, at least in part.[5] Some very poor specimens now in the museum, however, consist, not of tetrahedrite, but of chalcocite, with a little copper pyrites, the chief ore being cuprite. According to the Rájputána Gazetteer,[6] gray copper is said to have been found in the Khetri mines in Jaipur, but the authority for the statement is not given. The "black sulphuret," mentioned by Colonel Brooke, would seem to have been chalcocite.[7] Captain Drummond noticed, on the ascent of the Silawat pass, in Northern Afghánistán, "a vein or bed of iron ore, upwards of 30 feet in breadth, containing another vein of a mixture of iron and gray copper in a space about 2 feet wide." "At Dobundee," again, he writes, "on entering the valley I found at Shinkye, on the right bank of the rivulet, specimens of red oxide and gray copper, but discovered no regular vein at the time. In a ravine named Lahazour, about half a mile from Shinkye, I observed in a hornblende formation an outcrop of gray, vitreous, and red oxide of copper, accompanying a vein of spar principally calcareous. Beyond this, in another ravine named Zerazour, there is a thin vein of rich copper ore similar to the preceding for-

[1] Memoirs, G. S. I., Vol. IV, p. 216.
[2] The Copper Mines of Singhbhum, by C. Durrschmidt, pp. 11, 12, 30.
[3] Records, G. S. I., Vol. III, p. 88.
[4] Jour. As. Soc., Bengal, Vol. XX, p. 8.
[5] H. B. Medlicott: Memoirs, G. S. I., Vol. II, p. 35; F. R. Mallet: Records, G. S. I., Vol. I, p. 16.
[6] Vol. I, p. 14.
[7] Page 21.

mation still hornblende. * * * In the ravine of Chinarkhail I found a vein of copper pyrites cropping out in small quantity, and higher up, at Chenar, less than a quarter of a mile from thence, I found a vein of gray copper, about 7 inches wide, with a considerable proportion of iron. * * * The formations here are all hornblende."[1] Although using the term 'vein,' Captain Drummond says that all the ore in that part of the country is bedded, and conformable to the stratification of the containing rocks.

Gray copper is said by Captain Herbert to occur in the Dhanpur, Sira, Gangoli, Khari, and Shor Gurang mines, in Kumaun and Garhwál.[2] But, as he remarks that many distinct species were confounded under that name (three of which contained no antimony, and one neither antimony nor arsenic), it is more than doubtful whether any of the 'gray copper' he mentions was tetrahedrite. In the case of the Dhanpur mine, indeed, he says the ore in question contained "50 per cent. of copper, besides iron and sulphur."

Tetrahedrite occurs, in considerable quantity it is said, not far from Khatmandu, in Nepál. Specimens were presented by General Jung Bahádur to the Asiatic Society in 1853, which are now in the Geological museum, and have lately been subjected to analysis.[3]

The mineral has a metallic lustre, iron-black colour, and dark-brown streak, slightly tinged with red. It is uncrystallized, and occurs irregularly through a somewhat translucent quartz rock, which has a granular structure, with apparent traces of foliation, suggestive of its being a metamorphic quartzite rather than a true vein-stone. Azurite, malachite, melaconite, cervantite, smithsonite, ochre, calcite, &c., occur in association with the sulphide ore, most of them being probably results of its alteration. The sulphide is so mixed up with the gangue that it was

[1] Jour. As. Soc., Bengal, Vol. X, pp. 75, 77.

[2] Asiatic Researches, Vol. XVIII, Pt. I (1829), pp. 242, 243.

[3] F. R. Mallet: Records, G. S. I., Vol. XVIII, p. 235. The specimens in question are those which were examined by Mr. Piddington in 1854 (Jour. As. Soc., Bengal, Vol. XXIII, p. 170). The analysis given by him is as follows:—

Sulphur	1·60
Silex	3·60
Carbonate of protoxide of bismuth	34·80
,, copper	22·96
Per-carbonate of iron	25·62
Ox: cerium	9·40
Lanthanum?	2·80
	100·78

Regarding the mineral as a new carbonate, he gave it the name 'Nepaulite,' from the country whence it had been sent. But, as shown above, the analysis just quoted is entirely erroneous.

only by laborious picking that enough could be separated for an analysis, which gave :—

Sulphur	21·12
Antimony	25·17
Arsenic	1·32
Copper	38·69
Silver	traces.
Lead	·30
Iron	5·33
Zinc	2·44
Calcium carbonate	1·07
Magnesium „	·13
Insoluble gangue	·68
Oxygen, carbonic acid, water and loss	3·75
	100·00

The oxygen, carbonic acid, and water are due to malachite, azurite, and melaconite, from which the sulphide ore could not be wholly freed. Cervantite was also not improbably present in small quantity, although, like the calcium carbonate, not visible to the eye. The number of minerals of apparently secondary origin in association with the sulphide, and the somewhat large proportion in which they occur, seem to indicate that the specimens were obtained from near the surface. Hence it is not unnatural that the sulphide should be in a somewhat altered condition. As an indication of the exact composition of the fresh and unchanged mineral, the analysis is therefore unsatisfactory, but it suffices to show beyond all doubt that the mineral is tetrahedrite of a common type. The above figures correspond to the formula $R_4 (Sb\ As)_2 S_6 = R_{4\frac{2}{3}} (SbAs)_{2\frac{1}{3}} S_7$, the excess of metals over the proportion required for the formula $R_4(SbAs)_2 S_7$ being certainly in part, and probably wholly, due to the occurrence of some of them partly in an oxidized state, owing to the alteration of the mineral just alluded to.

Mr. O'Riley states that "specimens of copper ore have been brought from several islands of the Mergui archipelago, and all obtained appears to be of the same character, *viz.*, the gray copper ore, containing from 40 to 50 parts of the metal in combination with antimony, iron, and sulphur."

Freibergite.—The author continues: "An ore of silver, of which specimens have been received, was found to consist of silver, antimony, copper, and sulphur, producing about 35 per cent. of pure metal; its locality appears, from the information obtained from a Karen, to be in the range of hills near the head waters of the Hloni Bwai river,[1]

[1] The Hloni Bwai appears to be the river which joins the Haundrau at the town of Gyne or Gyeing, 20 or 25 miles E.N.E. of Maulmain. It is spelled "Lhine Boay" on the map in Selections from the Records of the Government of India, No. XXIX.

where old workings are said to exist."[1] This appears to be the only recorded instance of the occurrence of freibergite in India. The high percentage of silver, if correctly stated, is remarkable even for this mineral, but it may be noticed that 50 per cent. of copper is higher than in any published analysis of tetrahedrite, and close to the theoretical amount possible in a gray copper free from other basic metals, so that both statements may, perhaps, be accepted with some doubt.

[1] Journal of the Indian Archipelago (Singapore), Vol. III, p. 737.

III.—Chlorides.

Sylvite.—In 1873 a deposit of potassium and magnesium salts was discovered by Dr. Warth in the Mayo salt mines. They predominated through a thickness of 6 feet in a bed of *kallar*, or impure salt, but the deposit was lenticular, rapidly dying out laterally, so that the total quantity obtained was only 15 maunds. A portion consisted of sulphate of magnesium and potassium, the remainder being a white, or reddish, granular mixture of sylvite, rock-salt, and kieserite. An analysis by Mr. Tween gave :—

Potassium chloride	61·43
Sodium chloride	29·32
Magnesium sulphate	7·78
Water	2·10
	100·63

Some portions of the substance, however, consisted almost exclusively of sylvite.[1]

Salt.—Enormous deposits of rock-salt occur in the Salt range of the Punjab. At the Mayo mines there are five great beds, having an aggregate thickness of 275 feet, alternating with another 275 feet of *kallar*, or impure salt, the whole being intercalated in the upper part of about 1,000 feet of red marl and gypsum. Some individual beds of salt are over 100 feet in thickness. The saline strata underlie beds of doubtful Silurian age. Immense deposits of (eocene ?) rock-salt occur in the Kohát district, the thickness exceeding 1,000 feet in one place. A stratum of the same mineral (of undetermined age) exists in the native state of Mandi, in the North-Western Himalayas.[2]

Salt also occurs abundantly at the salt lakes of Rájputána, the shallow water of which is a more or less fully saturated brine, according to the season of the year. Around the margin, and sometimes over the whole (dry) bed, the ground is covered with a crust of salt crystals. The alluvial deposits also contain salt in some parts of India, which is utilised by means of brine wells ; and chloride of sodium is one of the constituents of the efflorescence known as *reh*, so common on the alluvial soil, in some parts of the country, especially in the upper provinces. The efflorescence from which nitre is prepared also contains more or less salt. (Pt. I, pp. 388, 395, 413, 415 ; Pt. II, pp. 486, 508, 558, 807 ; Pt. III, pp. 475, 496.)

[1] Mineralogische Mittheilungen, 1873, p. 135 ; Records, G. S. I., VII, p. 64 ; Memoirs, G. S. I., Vol. XIV, p. 80 ; Manual, Pt. III, p. 437.

[2] As pointed out by Mr. Wynne (Memoirs, G. S. I., Vol. XIV, p. 81), rock-salt is not known to occur in the valley of Káshmir, as stated in Dana's System of Mineralogy.

From a mineralogical point of view the colourless, transparent, cleavable, cubic crystals, which line the walls of fissures in the rock-salt of the Salt range mines are noticeable. There are specimens in the museum 2 and 2½ inches across, but, according to Dr. Warth, very much larger ones are found.[1] Some of those in the Sujewal and Purwalla mines have "the margins of the cube faces replaced, so that the solid angles have 6 bevelled edges."[2] The form combined with the cube in these crystals is doubtless the tetrakishexahedron $\infty O2$, the only form bevelling the cube solid angles, in the way mentioned, which has hitherto been observed. As products of the solution and re-crystallization of the mineral, salt is found, in some of the old workings of the same mines, in aggregations of long capillary crystals,[3] and in arborescent forms. The massive rock-salt is sometimes remarkable for the high degree in which cleavage is developed. There is in the museum a parallelopiped, illustrating this, measuring $14 \times 11 \times 7$ inches, and bounded entirely by natural cleavage faces.

"Very interesting is the occurrence of the casts of salt crystals on sandstone slabs in the upper green sandstone formation (of the Salt range). * * * The formation of the crystals is explained in the following way. On a flat shore covered with a layer of freshly deposited mud, after the evaporation of the salt water, the resulting salt crystals were formed in the mud in such a way that half of their surface was exposed and the other half lay buried. Further evaporation caused the mud to harden. After this had happened, the level of the sea-water again rose, and the tide flowing over the hardened mud dissolved the crystals, bringing sand which was deposited in a thin layer over the mud. This sand also entered into the spaces left by the dissolved crystals, forming casts of them. Other layers of mud and sand settled upon the first ones, and the same process of crystallization may have been repeated or not. In the hardened state in which we now find the layer,—the mud as marl, the sand in the form of sandstone slabs,—the casts of the crystals are all found as they ought to be found, *i.e.*, on the *lower* side of the sandstone slabs. They appear when the marl is washed away by the rain. Some crystals are very beautiful and show that pyramidal [4] form which is so characteristic of salt produced by evaporation."[5]

Below are analyses, by Mr. C. Hickie, of the mineral from the Salt range :—

	A.	B.	C.
Sodium chloride	94·60	92·84	92·80
Magnesium chloride	·71	·71	1·34
Calcium chloride	...	·42	1·16
Calcium sulphate	·77	·69	·92
Earthy matter	trace	trace	trace
Water and loss	3·92	5·34	3·78
	100·00	100·00	100·00

[1] Report on the Administration of the Inland Customs Department, 1869-70, Appendix H.

[2] A. B. Wynne : Memoirs, G. S. I., Vol. XIV, p. 80.

[3] *Ibid.*, p. 79.

[4] Hopper-shaped.

[5] Dr. H. Warth : Report on the Administration of the Inland Customs Department, 1869-70, Appendix H.

A.—Purest white crystallized salt from the Mayo mines.
B.—White salt as it is sold from depôt at Buggy mine.
C.—Red salt as it is sold from depôt at Soojewal mine.[1]

The analyses were made of the salt as sent into the market, and containing a considerable amount of water absorbed during storage, owing mainly to the presence of calcium and magnesium chlorides. Deducting the water (and loss) the above figures give—

	A.	B.	C.
Sodium chloride	98·46	98·08	96·44
Magnesium chloride	·74	·75	1·39
Calcium chloride	...	·44	1·21
Calcium sulphate	·80	·73	·96
Earthy matter	trace	trace	trace
	100·00	100·00	100·00

—which may be taken as near approximations to the composition of the purest freshly-mined salt.

Sal ammoniac.—An efflorescence of sal ammoniac is said to occur "generally through the volcanic region" of the Ghorband valley in Afghánistán.[2] In some deserted gold mines about 10 miles west of Coopum railway station, in the Salem district, Madras, "great numbers of rock-pigeons have taken up their abode * * * and eggs innumerable and young pigeons are seen in the clefts of the rock. The great heap of excreta of these birds (not less than 20 feet in height) testifies to the age of these mines. The whole of the rocks below are coated with sal ammoniac from the urine of the pigeons."[3]

Chlorocalcite.—From crevices between some ejected blocks, near

[1] *Op. cit.*, and Memoirs, G. S. I., Vol. XIV, p. 77. The colouring material which gives a red tint to much of the salt, and which remains as a sediment when the mineral is dissolved in water, has been subjected to microscopic examination by Dr. H. Giraud. He arrived at the conclusion that it consists altogether of organic remains, partly infusorial, partly vegetable. In a specimen of the salt analysed the sediment amounted to 1·6 per cent. and was regarded by him as 'silicate of iron.' (Jour. As. Soc., Bombay, Vol. I, p. 303.) Dr. Fleming says: "The colour of the red salt is not, as might be supposed, derived from a salt of iron or manganese, but is probably of an organic nature." (Jour. As. Soc., Bengal, Vol. XXII, p. 243.) The sediment from a specimen of red salt, from the Mayo mines, was found by the present writer to contain a considerable amount of iron soluble in hot HCl, after which treatment the remaining portion of the sediment was no longer red. According to Bischof, the ochreous deposits of salt brine, from Colberg and Dürrenberg, contain infusoria. These, however, are yellow, owing their colour to hydrated oxide of iron. (Chemical Geology, Vol. I, p. 169.)

[2] P. B. Lord: Jour. As. Soc., Bengal, Vol. VII, p. 536. The present writer has been informed, by Mr. C. L. Griesbach, that there are no recent volcanic rocks in the valley.

[3] Gold: its Occurrence and Extraction, by A. G. Lock, p. 309. Original authority not given.

For artificial production of sal ammoniac in the Karnál district, Punjab, *vide* Baden-Powell's Economic Products of the Punjab, Vol. I, p. 89.

the middle of a solfatara in the crater of Barren island (bay of Bengal) "superheated steam" (as noticed by the present writer in 1884) "with sulphureous vapour, issued rather copiously, the column, as it rose into the air, being visible from the landing place, or even some distance out at sea. The temperature of the steam at the point of issue was 219° F., or 9° above the boiling point of water at the elevation of the crater. * * * The surfaces of the rock near the vents were covered with a white vesicular stalactitic substance, and with a red and orange deliquescent matter. The former was found to consist mainly of a basic sulphate of alumina, with a little calcium chloride, while the red incrustation consisted of calcium chloride, with basic sulphate of alumina and ferric oxide." [1] It was not perceptibly moist when freshly taken from the rock, but soon deliquesced afterwards.[2]

Atacamite.—There is a fine specimen of chalcocite in the Museum, from Garimanipenta, in the Nellore district,[3] which is intersected by small irregular seams of atacamite, in dark emerald-green translucent crystals, together with some malachite.[4] Were the mines re-opened, atacamite might, perhaps, be found in some quantity.

[1] Memoirs, G. S. I., Vol. XXI, p. 269.

[2] According to Mr. Alexander (Edinburgh Philosophical Journal, Vol. XI, p. 308), the water of the Lonar lake, in Berar, contains a considerable quantity of calcium chloride, but several other analysts are agreed as to its containing none. Malcolmson says that it contains "no lime." (Trans. Geol. Soc., 2, V, p. 564.) Dr. Heyne states that the water of some of the wells in the neighbourhood of Samulkota, in the Godávari district, is brackish, on account of its containing calcium chloride. (Tracts on India, p. 240.)

[3] Page 19.

[4] F. R. Mallet : Records, G. S. I., Vol. XII, p. 171.

IV.—Fluorides.

Fluorite.—Although this mineral has been reported from a few localities, it has not as yet been discovered abundantly in any part of India (Pt. III, p. 449). Dr. Heyne notices its occurrence in the Carnatic, but does not mention the place.[1] Green and purple fluorspar, with galena, has been found in a lode, of which the principal gangstone is quartz, near the village of Ránitalao, 3 miles west of Chicholi dák bungalow, in the Raipur district, Central Provinces.[2] The same mineral has been observed in the Bhánrer limestone, near Rewah, but is extremely rare.[3] At Wángtu bridge, over the Sutlej, in the North-Western Himalayas, a very few sea-green crystals are scattered through the granite dykes there.[4] Dr. Romanis has lately discovered pink and green fluorspar, in limestone, at Kemau, a village in the Amherst district on the Thoung-Yeng river, 65 miles E. 15 S. from Maulmain,[5] and bluish crystals of the mineral are said to have been found in the northern part of the same district.[6]

[1] Tracts on India, p. 193.
[2] Records, G. S. I., Vol. I, p. 37, W. T. Blanford. *Ibid.*, Vol. III, p. 44.
[3] Memoirs, G. S. I., Vol. VII, p. 122.
[4] Memoirs, G. S. I., Vol. V, p. 166.
[5] Report on Minerals in Tenasserim, p. 3.
[6] Natural Productions of Burma, by the Rev. F. Mason, p. 31.

V.—Oxygen Compounds.

I.—Oxides.

1.—Oxides of elements of Series 1.

A.—Anhydrous Oxides.

(*a*) Protoxides—General formula RO (or R'_2O).

Cuprite has been found near Veppur, in Trichinopoly, with tetrahedrite, &c., as described under the latter mineral.[1] In the Singhbhum mines "red copper ore" occurs in solid masses, from the size of a nut to several feet in diameter, in a siliceous matrix, sometimes filling the whole lode and enclosing angular pieces of quartz, sometimes in strings and flakes ramifying through the rock. This is the most important ore, seldom indeed pure, almost always mixed with black copper and iron oxide. As the malachite is due to the further decomposition of this ore, so is the latter of glance copper; some specimens show the three states. It is difficult to find red copper entirely free from copper-glance; apparently pure specimens have given 8 per cent. of sulphur. The mixture with iron oxide varies from 0·25 to 18 per cent. It is always mixed, too, with black copper; and it was interesting to know if the proportion were constant: analysis showed it to vary from 63·7 per cent. sub-oxide and 33·6 of oxide, to 50·14 per cent. of sub-oxide and 46·74 of the oxide. It is only an indefinite mixture. Often the oxide is in excess, the ore being dark brown, with black metallic streak. The common variety is brown-red to cochineal-red, with red streak, and, in pure pieces, a fine crystalline texture. This quality, with hardness of 3, sp. gr. 5·623, gave[2]—

Red oxide	63·72
Black oxide	33·60
Silica	1·02
Oxide of iron and alumina	·75
Lime	·64
Magnesia	·10
	99·83

"Tile copper ore" is mentioned by Mr. Piddington as occurring at Bairuki, near Deoghar in the Sánthal pargannahs, but in his analysis he represents the copper as present in the state of "peroxide."[3] Ordi-

[1] Page 29.

[2] M. E. Stœhr: Neues Jahrbuch für Mineralogie, &c., 1864, p. 146; Records, G. S. I., Vol. III, p. 89.

[3] Jour. As. Soc., Bengal, Vol. XX, p. 9.

nary cuprite and tile ore have been found at Birman ghát, in the Narsinghpur district, Central Provinces, with chalcocite, malachite, and azurite.[1] There are specimens, in the museum, of red copper with malachite, &c., in a quartzose gangue, from Sorai, in the Lalitpur district, North-Western Provinces.[2] The ore at Gugra, Rájgarh, and Rajauri, near Ajmere, is said to be "ferruginous red oxide of copper."[3] Cuprite occurs, with native copper, in the Zánskar river, in Káshmir,[4] and with chalcocite &c., in the Salt range.[5] It has been found by Captain Drummond in the Ghilzie territory, south-east of Cabul, with chalcocite and native copper at Tezeen, and with tetrahedrite at Dobundee.[6] Specimens of red copper with the native metal were also obtained, which were said to have been brought from the hills of Goorgee Mydan, not far from Acoorookhail.[7] Captain Hutton states that the mineral occurs in the Hazára mountains.[8]

Melaconite occurs, with other copper ores, in the old mines at Garimanipenta, in Nellore;[9] and also in those of Singhbhum, where it is found both mixed with a large proportion of cuprite, as previously described,[10] and also in thin strings and coatings comparatively free from red oxide. According to M. Stœhr this purer mineral "is used by the native beauties as a black dye for the teeth." A specimen of melaconite from Upper Burma, in the possession of the Political Agent at Mandalay, was said to contain 79 per cent. of copper, and the mineral was reported to occur in large quantity.[11]

(*b*) Sesquioxides—general formula $\mathrm{R_2O_3}$.

Corundum.—*Sapphire* is found, along with many other varieties of corundum, in the ruby mines of Upper Burma, described more fully below. According to Mr. Spears, the sapphires are much rarer than the rubies, although those found are generally of a larger size. "Stones of 10 to 15 ratties[12] without a flaw are common, whereas a perfect ruby of that size is hardly ever seen. The largest perfect sapphire I ever saw weighed 1 tikal.[13] It was polished, but I have seen a rough one weighing 25 tikals.[14] * * * For every one hundred rubies, I do not

[1] Pt. III, p. 257.
[2] *Vide* "Tetrahedrite," p. 29.
[3] Jour. As. Soc., Bengal, Vol. IV, p. 583.
[4] Page 4.
[5] Page 20.
[6] Page 5.
[7] Jour. As. Soc., Bengal, Vol. X, p. 77.
[8] Calcutta Jour. Nat. Hist., Vol. VI, p. 599.
[9] Jour. As. Soc., Bengal, Vol. II, p. 94.
[10] Page 38.
[11] Extract from MSS. Diary of Political Agent, July, 1873.
[12] About 6 to 9 carats.
[13] 79·5 carats.
[14] 1,988 carats, or a little over 13 oz. Troy.

think they get one sapphire."[1] Mr. Crawford, however, says that "the blue sapphire is more common, and cheaper" (than the ruby); "one specimen exhibited to us weighed 951 carats, but it was not perfect."[2] Tavernier also states that there are found "great quantities of rubies and espinels, or mothers of rubies, yellow topazes, blue and white sapphires, jacinths, amethysts, and other stones of different colours."[3] According to Mr. Streeter, large and fine sapphires have been imported from Burma for a long time past.[4]

Captain Newbold states that sapphire is occasionally found, with common corundum, in the Salem district, Madras, and in the valley of the Cauvery;[5] and, according to the Central Provinces Gazetteer,[6] the same gem occurs in the neighbourhood of Paloncha, in the Upper Godávári district, but no authority for the statement is given.

In 1882 a very remarkable discovery of sapphires was made in the Zánskar range of the Káshmir Himalayas, and within a short time such quantities of the gem were thrown on the market as to materially lower its value. Owing to the secrecy observed by the discoverers, very conflicting accounts were in circulation as to the place where the stones had been found, and even now there is some doubt on the point, while our knowledge of the mode of occurrence of the mineral is meagre in the extreme, no expert having as yet visited the spot, which is strictly guarded by the Maharája's officials. It appears, however, that the locality is in the Zánskar range, within some miles of the village of Machél (Lat. 33° 25′, Long. 76° 21′), and near the line of perpetual snow. According to one informant it is about half a day's journey from the top of the Umási pass, 2 or 3 *kos* to the east of Machél; but according to another it is best reached from the Pentse pass, which is 30 miles north of the village.[7] The rock in which the sapphires were discovered, which was doubtless a crystalline one, as the whole of the Zánskar range is composed of such,[8] appears to have been decomposed and crumbly at the surface, so that the gems could be taken out "like potatoes." Further in, the rock was more solid, and they could only be extracted with the aid of tools. A very large quantity appears to have been obtained, and the first lots that were brought across the snow are said to have been sold for a mere trifle, owing to the ignorance of the carriers as to their value. Subsequently, however, when the fact that the

[1] Yule's Mission to the Court of Ava, p. 248; Balfour's Cyclopædia, art. Ruby.

[2] Mission to Ava, Edinburgh New Phil. Jour., 1827, p. 366.

[3] Travels in India, p. 143. With reference to topaz and amethyst see p. 44.

[4] Precious Stones and Gems, 4th edit., p. 168.

[5] Jour. Royal As. Soc., Vol. VIII, p. 153.

[6] Page 506.

[7] Rev. A. W. Heyde: Records, G. S. I., Vol. XV, p. 140; Memoirs, G. S. I., Vol. XXII, p. 335.

[8] R. Lydekker: Memoirs, G. S. I., Vol. XXII, p. 294.

stones were real sapphires was known, they rose in price to ₹100 per tola in the rough, and considerably more for really promising pieces.

The writer has had the opportunity of examining numerous specimens, some of which are now in the museum. A large proportion were crystals; the remainder being irregular pieces, which may, however, have been broken after extraction. The mineral is partly bluish-white and translucent, partly transparent and of a rich blue colour, the two varieties being irregularly intermixed. It is the latter, of course, which constitutes the sapphire, the bluish-white part being rather corundum. A large proportion of the crystals are milky, with variously-sized portions of sapphire irregularly scattered through them. Others, again, are mainly sapphire, and are only milky here and there. More rarely the colour shades into yellow, brown, or red.

Small crystals of dark brown tourmaline are not uncommonly implanted on the surface, or imbedded in the interior, of those of sapphire, and the latter sometimes include cavities towards the centre, in which small crystals of similar tourmaline are often found.[1] Besides these, larger crystals of tourmaline are said to be invariably associated with the sapphire, in the matrix.

The sapphire crystals which have come under the writer's notice are double hexagonal pyramids, with the basal plane sometimes well developed, but very often quite small, or almost obliterated. They are frequently flattened, so that eight of the pyramidal planes are much larger than the remaining four. The pyramidal planes are generally deeply striated parallel to the edges between them and the basal plane. Many of the crystals are very irregular, the corresponding angles, measured on different pairs of faces, frequently varying by several degrees. The following may be taken as illustrations of their general characters :—

Fig.	Dimensions of Crystal.	Mineralogical Character.	Crystallographic Character.
2	1¼″ long × ⅞″ (one half of crystal only).	Central part of crystal sapphire; apex nearly colourless.	2P2. 0R. Basal planes nearly obliterated.
3	2½″ long × 1¼″ × ⅞″	Milky and sapphire portions of crystal irregularly intermixed.	⅝P2. 0R. Basal planes very small.
4	1½″ long × 1¼″ × 1″	Mainly sapphire, but partly milky. Colours irregularly distributed.	⅝P2. 0R. Basal planes well developed. Crystal flattened.
5	3″ long × 1⅜″ × 1¼″	Milky, with sapphire irregularly intermixed.	4P2. 0R. Basal planes fairly developed. Crystal flattened.

[1] F. R. Mallet, Records, G. S. I., Vol. XV, p. 138.

The writer has seen some very good cut gems from the Zánskar range, and it is believed that very fine ones have been in the market.

At the time the above-mentioned sapphires were discovered, there were vague stories in circulation of the mineral having been found in other parts of Káshmir and the adjoining districts,[1] but as nothing has since been heard of these it is unnecessary to mention them here.

Mr. J. Calvert has stated that he found "sapphires worth ₹2,500 each, besides other gems,"[2] in the Upper Raini valley, near the head-waters of the Beas, below the Hamta pass, in Kulu. The rocks there are gneiss and mica schist,[3] and the locality is about 100 miles to the south-east of the Umási pass, noticed above in connection with the sapphires of the Zánskar range.

Ruby.—The celebrated ruby mines of Upper Burma,[4] "which have always afforded, and still continue to afford, the finest gems of this description in the world," are scattered over an area of some 25 or 30 square miles. Mogok (or Mogout), which is the ruby mining centre, is in lat. 22° 55′, long. 96° 30′, and elevated 4,100 feet above the sea, while Kapyun (or Kyat-pyen[5]) and Kathè are 5,000. Surrounding the above elevated tract are hills of which the culminating peak rises to 7,800 feet.[6] It appears, from information obtained by Mr. Bredemeyer and Dr. Romanis, that the rubies occur in three ways—*in situ* (imbedded in white crystalline limestone(?)); loose in the soil on the hill sides; and in gem-bearing gravel. The limestone (?)[7] is the original home of the mineral, whence it has been washed down into the gravel bed, in which, apparently, all the most important mines are situated.

The gems are also found at the marble hills of Sagyin, 16 miles north of Mandalay. It would seem that gems are obtained direct from the limestone there, but these are said to be too light in colour to be of much value.

[1] Rev. A. W. Heyde: Records, G. S. I., Vol. XV, p. 140. See also Precious Stones and Gems, by E. W. Streeter, p. 168, where it is stated that sapphires have been found in large quantities near the Lácha pass. Is this the Bára Lácha pass, at the head of the Chandra-Bhaga?

[2] Kulu: its beauties, &c., p. 44.

[3] Col. McMahon: Records, G. S. I., Vol. XII, p. 65.

[4] Within the next few months a systematic examination of the mines will probably be made by a member of the Geological Survey, when m re detailed and accurate information will doubtless be collected than is now available.

[5] Mr. Prinsep has suggested, and doubtless correctly, that the "Capelan mountains" (originally mentioned by Tavernier, and now given in most works on mineralogy as the locality where the Burmese rubies are found) are the mountains of the Kyat-pyen district. (Jour. As. Soc., Bengal, Vol. II, p. 75.)

[6] The writer is indebted for the above data to Captain J. R. Hobday, of the Survey of India, who has lately been over the entire ground. Captain Hobday is of opinion that the ruby-bearing area is much larger than at present known, and mentions that the gem is said to exist in the Mainlung and Toungbine districts, to the south and east of Mogok.

[7] Later information would appear to render it doubtful whether limestone is the most usual matrix.

According to Mr. Crawford, "the red sapphire, or oriental ruby, the oriental sapphire, the white, the yellow, the green, the opalescent, the amethyst and girasol sapphires, the spinel ruby, and the common corundum, or adamantine spar," are all found. Most of these varieties are also mentioned by other authors. Spinel occurs in great abundance, and is called by Tavernier the "mother of ruby."

"The rubies are," as stated by Dr. Oldham, "for the most part small, not averaging more than a quarter of a ratti,[1] and, when large, are generally full of flaws. Well-marked crystals occasionally occur, but the vast majority of the stones are well rounded and ground down. It is a very rare case to find a large ruby without flaws; and Mr. Spears states that he has never seen a perfect ruby weighing more than half a rupee."[2] Perfect rubies of 10 or 15 rattis[3] are "hardly ever seen." Mr. Crawford remarks that "the oriental ruby, perfect in regard to water, colour, and freedom from flaws, is scarce and high-priced even at Ava. * * * His Majesty last year got but one large ruby; this weighed about 140 grains[4] avoirdupois, and was considered a remarkable stone." Stories, however, are not wanting respecting gems of much larger size; but these must be accepted for what they are worth. Vincent le Blanc, according to Tavernier, reported that he saw rubies in the King's palace as big as eggs, but the latter author hints very broadly that he does not believe it. Dana says, without citing the original authority, that "two splendid red crystals, having the form of the pyramidal dodecahedron, and 'de la longueur du petit doigt,' with a diameter of about an inch, are said to be in the possession of the King of Arracan."[5] Mr. Bredemeyer, a German mineralogist, who spent some time at the mines, and was in a position to form a trustworthy opinion, thought that, with care, rubies as large as pigeon's eggs could be extracted.[6]

Crystals of Burmese ruby in the museum show the following combinations:—

∞P2. 0R. R. (fig. 6).
0R. R. ∞P2. (fig. 7).
∞P2. 0R. R. $\frac{4}{3}$P2.
0R. ∞P2. $\frac{4}{3}$P2. R. (fig. 8).

[1] Rather less than half a grain.
[2] 28·4 carats.
[3] About 6 to 9 carats.
[4] 44·2 carats.
[5] System of Mineralogy, p. 140.
[6] The authors quoted with reference to the Burmese ruby are—Tavernier, Travels in India (1684), p. 143; Crawford, Edinburgh New Phil. Jour. 1827, p. 366; Père Giuseppe d'Amato, Jour. As. Soc., Bengal, Vol. II (1883), p. 75; Dr. T. Oldham, Appendix to Yule's Mission to the Court of Ava (1858), p. 347; Captain G. A. Strover (quoting Mr. Bredemeyer), Indian Economist, Vol. V, p. 14; Dr. R. Romanis, some recent notes.

The above vary in weight from about two thirds to four and a half carats. A parcel of Burmese rubies, belonging to Mr. Streeter, which the writer was allowed to examine, some months ago, consisted mainly of irregular pieces, but there were two crystals, respectively weighing 22 and 29 carats, and having the faces ∞P2. 0R. R. $\frac{4}{3}$P2.

Dr. J. Lawrence Smith gives the analysis quoted of "ruby of India."[1] Although more probably Burmese, it may have been from Siam or Ceylon—

Alumina	97·32
Magnetic oxide of iron	1·09
Silica	1·21
	99·62

It is not stated in what form the magnetic oxide of iron was present.

Dr. Helfer speaks vaguely of rubies having been found in Tenasserim, east of the Tenasserim river, but he says most of the specimens he saw were garnets.[2]

In a paper on the Corundum of Southern India, Captain Newbold states that "fine rubies have, from time to time, been discovered in many of the corundum localities just enumerated, associated with this gem, particularly in the gneiss at Viralimodos and Sholasigámany. The natives inform me that it occurs also in the Trichingode taluk and at Mallapollaye, but it is rare, comparatively speaking."[3] These places are in the Salem district, Madras. Dr. Clark mentions coarse rubies having been brought to him from Mysore,[4] and Lieutenant Kittoe that stones which he collected in the Máhanaddi, near Katták, as garnets, were pronounced by a native jeweller to be rubies.[5] As remarked by Mr. Ball, however, the former opinion was not improbably correct. According to the Central Provinces Gazetteer,[6] "rubies were formerly obtained near Wairágarh, in the Chanda district, but the mines have long since been abandoned."

Rubies are said by Mr. J. Calvert to have been found in Kulu, but he does not mention the locality.[7] It may perhaps be inferred that he alludes to the Raini valley, referred to above under sapphire. It has been reported that the sapphires of the Zánskar range are accompanied

[1] American Jour. Sci., 2nd Series, Vol. XI, p. 54; and Vol. XLII, p. 89.
[2] The Provinces of Ye, Tavoy, and Mergui, p. 34.
[3] Jour. Roy. As. Soc., Vol. VII (1843), p. 224.
[4] Madras Jour. Lit. & Sci., Vol. IX, p. 121.
[5] Jour. As. Soc., Bengal, Vol. VIII, p. 372.
[6] Page 135.
[7] Kulu: its beauties, &c., p. 72.

by rubies,[1] but the latter would seem to be extremely rare in comparison. A correspondent of the *Delhi Gazette* described a crystal which was white and opaque in the centre, with a streak of sapphire at one side (end?) and of ruby at the other; and Mr. A. G. Young mentions having seen a small fragment of "true oriental ruby, perfectly clear, and of a beautiful water," brought from the same region.[2]

For some years previous to 1879, ruby mines, belonging to the Amir of Afghánistán, were worked at Jagdalak, 32 miles east of Kábul, and probably mining is carried on there still. They were visited in the year mentioned by Major G. Stewart, and it appears from information, and specimens of both matrix and gems, supplied by him, that the rubies are imbedded in white crystalline micaceous limestone. Two crystals now in the museum[3] show the combination ∞P2. 0R. R. (fig. 9). These respectively weigh rather more than 1 and 1½ carats, but the writer has seen one considerably larger. It had the same faces, but with R. more largely developed.

Mr. Streeter mentions having possessed a ruby of 10½ carats, from the mines of Gandamak.[4] These are perhaps the same as those just mentioned, Gandamak and Jagdalak being only 20 miles apart.

On comparing the crystallographic characters given above for the sapphires of Káshmir and the rubies of Burma and Jagdalak, it will be seen that the former are distinguished by the absence of the prismatic faces, and the predominance of pyramidal ones, the basal planes being sometimes nearly obliterated. In the crystals of ruby, on the other hand, the chief planes are prismatic, basal and rhombohedral, the pyramidal being uncommon. The same difference is noticeable in the crystals from Ceylon in the museum. But the total number, both Indian and Cingalese, is too small to generalize from with safety. It appears to be a well-known fact that sapphire crystals commonly attain much larger dimensions than those of ruby.

Oriental Topaz.—Yellow sapphires are amongst the varieties mentioned by Mr. Crawford as occurring in the Burmese ruby mines. Tavernier and the Père d'Amato say that topazes are found, referring evidently to the same gem. Tavernier, indeed, notices of the Burmese, that "saphirs they call blue rubies, amethysts they call violet rubies, topazes yellow rubies, and so of other stones."

Writing of the sapphires from the Zánskar range, Mr. Heyde has described a crystal which "looked for about an inch like topaz, the colour

[1] Rev. A. W. Heyde: Records, G. S. I., Vol. XV, p. 141.

[2] American Jour. Sci., 3rd Series, Vol. XXVI, p. 339.

[3] Erroneously described as spinel in Proceedings, As. Soc., Bengal, 1880, p. 4. That spinel may occur in the mines, as well as true ruby, is not unlikely, considering the matrix, but the only specimens hitherto examined are of the latter mineral.

[4] Precious Stones and Gems, 4th edit., p. 161.

being that of a deep-coloured sherry wine, quite transparent, the two colours (blue and yellow) running gradually into each other."

Oriental Emerald and *Oriental Amethyst* are also found in the ruby mines of Burma. The former is said to be very rare. Mr. Crawford further notices *girasol sapphire*, of which he saw two or three very fine specimens, *opalescent* and *white sapphire*, from the same mines. It would appear that the last-mentioned variety has been observed in crysals from the Zánskar range.[1]

Corundum.—Besides the gem forms of the mineral, India is particularly rich in corundum, using the word in the more restricted sense of the term. There are two distinct varieties: crystallized corundum, which is abundant in the metamorphic rocks of many parts of Southern India; and granular massive corundum, of which an immense deposit exists in South Rewah. Crystallized corundum has been reported from numerous districts[2] (Part III, p. 421), but only two writers seem to have devoted special attention to its mode of occurrence. Count de Bournon describes the corundum of the Salem district as occurring in crystals disseminated through a granular matrix composed of a mineral to which he gave the name indianite,[3] which has since been identified as a granular form of anorthite. Associated with the corundum in the same matrix are found hornblende, felspar, fibrolite, epidote, garnet, magnetite, and more rarely quartz, mica, talc, and steatite. Of these minerals, hornblende, generally of a deep black colour, is the most abundant. The author, indeed, was of opinion that it is principally when the rock is hornblendic that it contains corundum.[4] Captain Newbold remarks that "Bournon considered indianite and fibrolite to be the matrix of corundum in Southern India. * * * I have always found it, both in Mysore and Salem, in talc, mica, or hornblende schist, associated with iron ore, asbestos, and sometimes indianite and fibrolite. It occurs imbedded in the rock in grains and crystals."[5] It would appear from this that Newbold considered that indianite plays a more subordinate part in

[1] A. G. Young: American Jour. Sci., 3rd Series, Vol. XXVI, p. 339.

[2] It should be noted that garnet, both massive and in crystals, sometimes passes under the name of corundum in Southern India; a fact recognised by Dr. Heyne so far back as 1814 (Tracts on India, p. 193). Specimens of both varieties of garnet, bought at Madras, were recently sent to the museum here as corundum. On this account there is reason to suspect that some of the published accounts respecting the latter mineral may be untrustworthy.

According to Mr. A. G. Young, corundum, both crystallized and massive, occurs with the sapphires of the Zánskar range, in Káshmir (American Jour. Sci., 3rd series, Vol. XXVI, 1883, p. 339).

[3] *q. v.*

[4] Phil. Trans. Royal Soc., 1802, p. 282; Observations sur quelques-uns des minéraux, soit de l'Ile de Ceylan, soit de la Côte de Coromandel, 1823, p. 20.

[5] Jour. Roy. As. Soc., Vol. VIII, p. 153.

connection with corundum than was supposed by De Bournon, and as the former author wrote from personal observation in the field, his opinion must be regarded as carrying more weight than one formed only from the examination of specimens sent to Europe.

The corundum at the mines near Gram, in Mysore, is said by Captain Newbold to "occur in decomposed beds of a talcose slate, to which gneiss is subordinate, associated with nodules of indurated talc, and of a poor quartzy iron ore: asbestos, chlorite, actinolite, and schorl were found imbedded in the talcose slate." Again, "at Namaul and at Viralimodos, on the north bank of the Cauvery, in the Permutty taluk, Salem district, corundum occurs imbedded in gneiss, and a grayish earth, resulting in part from the disintegration of that rock."[1]

According to Count de Bournon, the commonest crystalline combination is the simple hexagonal prism terminated by the basal planes ∞P2. 0R. (figs. 10, 11). "It is indeed, in certain districts, particularly in the Carnatic, almost the only form that is met with. In all these crystals, the prism here spoken of differs considerably in its length; sometimes it is very much elongated, at other times it is very short." Hexagonal pyramids, terminated by the basal plane, occur but rarely. Figures of this combination are given, but no symbols or angular measurements. Crystals are also drawn of the first-mentioned combination with the addition of rhombohedral planes.[2] In an article on the mineral products of the Madras presidency, in the Indian Journal of Arts, Sciences, and Manufactures[3] it is said that the corundum of Salem, and the adjoining districts, "occurs under such a variety of forms, and sometimes in such large fragments, and so perfectly crystallized, that it deserves a separate description. There are four distinct species of it. One of a pale apple-green, in large flattened slabs about the size of the fist, or even larger, with imperfect crystallization, but of beautiful adamantine and sparry fracture, with a fine play of colours, when held in the sun. The second variety occurs in long, barrel-shaped, hexagonal crystals, one of which was about five inches in length, of a purplish-red colour. The third is found in the form of truncated hexagonal pyramids of every shade of blue, and bearing considerable resemblance to sapphire. The fourth variety is in rolled amorphous masses of a dirty-green colour and small size."

Mr. Chenevix obtained the following results in analyses of Indian corundum,[4] but allowance should perhaps be made for the date at which

[1] *Ibid.*, Vol. VII, pp. 219, 224.

[2] Phil. Trans. Royal Soc., 1802, p. 250.

[3] Part VI, p. 441.

[4] Phil. Trans. Royal Soc., 1802, p. 332. Beudant says that "all the analyses of this chemist are erroneous" (Traité de Minéralogie, p. 368), but Dana appears to hold a different opinion (Mineralogy, p. 340).

they were executed. Comparing them with those quoted below, it may perhaps be inferred that the loss was mainly due to water—

	Carnatic.	Malabar.	Ava.
Alumina	91·0	86·5	87·0
Oxide of iron	1·5	4·0	4·5
Silica	5·0	7·0	6·5
	97·5	97·5	98·0

Dr. J. Lawrence Smith has published the following analyses of "corundum of India" (no special localities given), commenting, at the same time, on the presence of water, not only in the corundum of India, but of that from other localities also. Its presence in corundum and absence in sapphire and ruby, he considered to indicate that the first named was formed under conditions different from those under which the gems were produced:—

	(*a*)	(*b*)
Alumina	93·12	84·56
Magnetic oxide of iron	·91	7·06
Lime	1·02	1·20
Silica	·96	4·00
Water	2·86	3·10
	98·87	99·92

The 'effective hardness,' taking Ceylon sapphire as 100, was found to be[1]—

Sapphire of India (Ceylon)	100
Ruby of India	90
Corundum of India (*a*)	58
Ditto (*b*)	55

Between Pipra and Kadopáni, two villages in the state of Rewah, near the right bank of the river Rehr, and about 14 miles south-west from the town of Singrauli, in the Mirzapur district, there is an immense deposit of granular massive corundum. It has been traced for about half a mile, and, where thickest, has a breadth of many, perhaps 30 or more, yards; the bedding is vertical, or at a high angle, the rocks on either side being gneiss, hornblende rock, and quartz schist, &c. The corundum differs from emery in containing but a small proportion of iron; there is not sufficient magnetic oxide to visibly affect a magnetic needle. It is a reddish, sometimes purple or gray, finely granular rock, through which microscopically minute crystals of rutile are frequently disseminated. The same mineral sometimes occurs in larger crystals in

[1] American Jour. Sci., 2nd Series, Vol. X, p. 362; Vol. XI, p. 54; Vol. XLII, p. 89.

the seams of the rock, which are, however, generally filled with emerald-green euphyllite and black tourmaline.[1]

Pieces of a light gray, or grayish-white, finely-granular corundum, containing microscopically minute specks of a translucent, dark-red mineral (probably rutile), have been found at the village of Nongryniew, two days' journey north-west of Nongstoin in the Khási hills, but the mineral has not been discovered *in situ*.[2]

Hematite.—There are few countries, perhaps, more bountifully supplied with this mineral than India. It is found in rocks of various ages, and in innumerable parts of the country. In most instances the mineral occurs in beds, although lodes are not wanting either. Some deposits, like those of the Chánda and Jabalpur districts, in the Central Provinces, where entire hills of the mineral are found, and those of Nimár, Bijáwar, and Gwálior, in Central India, are of extreme richness, while a long list might be given of places where the ore occurs in abundance. Notices of these may be found in Mr. Ball's chapter on Iron (Pt. III, p. 335).

The iron ore of Rájgarh, in the state of Ulwur, Rájputána, has been examined lately by Mr. T. F. Andresen, M.E. It occurs in a series of rolling hills near the town, and "Mr. Andresen has ascertained that this large deposit of iron ore extends in a regular belt for a distance of over $1\frac{1}{2}$ miles in length, and has an average width of 500 feet; that it has been followed to a depth of over 120 feet; that it consists chiefly of rich red and brown hematites, specular iron; and that it is notably devoid of the presence of foreign minerals."[3]

The iron ores of the Jabalpur district were examined by the writer in 1883. The hematite deposits are all bedded, and occur near the base of the Lora group of the transition series. Schistose hematite and micaceous iron, semi-ochreous hematite, manganiferous hematite, and hematite interbanded with jasper, are all abundant. At Agaria an entire hill is composed of the first-named ores, and smaller ones occur near Sarroli. In the Jauli mine there is a rich deposit of more or less ochreous mineral, while in the Lora range, and at Gosalpur, there is a strong band of schistose manganiferous hematite. Analyses of all the above ores have been made, but as these are interesting from a metallurgical rather than a mineralogical point of view, it is scarcely necessary to quote them here. The proportion of ferric oxide ranges up to 97·54 per cent.[4]

A descriptive list of the numerous known hematite deposits of the lower Narbada valley is given by Mr. P. N. Bose, in a recent

[1] F. R. Mallet: Records, G. S. I., Vol. V, p. 20; Vol. VI, p. 43.

[2] *Ibid.*, Vol. XII, p. 172.

[3] Mining Journal, 30th August 1884, p. 1029.

[4] Records, G. S. I., Vol. XVI, p. 96. For further analyses of the Jabalpur ores, as well as of those from Chanda, see Journal, Iron and Steel Institute, 1886 (abstracted in 'Iron,' 26th November 1886).

memoir on that region.[1] It appears from this that the mineral occurs in the metamorphic, transition, and Gondwána rocks, in superficial deposits, and also in true veins, some of these veins occurring along fault-lines.

The occurrence of hematite, in some quantity, as the cementing material of a breccia, near the Singareni coal-field, in Hyderabad, has been noticed by Mr. R. B. Foote.[2]

More recently the same author has described the occurrence of "splendid hematite ore," in unlimited quantity, in the Sandur hills, Bellary district, where it occurs interbanded with schist and trap.[3]

Martite.—The occurrence of bedded iron ore in the eocene strata north-west of Kotri, in Sind, has been described by Mr. W. Blanford.[4] Masses of magnetite, and bands of hematite and limonite, more or less pure, occur, in considerable quantity, in many places. From the hills east of Lainyan, in that neighbourhood, Mr. Fedden has brought crystals, some octahedral, others a combination of the dodecahedron and octahedron, the latter up to two inches in diameter. They have a red streak, and act on the magnetic needle comparatively faintly, the iron having been nearly all peroxidized.

Ilmenite.—In his 'summary of the geology of Southern India,' Captain Newbold remarks that "iron ore slightly titaniferous is found over the whole hypogene area. Menaccanite I found among the iron sand and gold dust in the bed of the Doni rivulet among the Kupputgode hills (Southern Mahratta country), and in some of the rivulets of the Ceded Districts"[5] (Berars); and again, "titaniferous iron sand is found in the beds of brooks and rivers running over the trap." Dr. Walker says that titaniferous iron sand is found abundantly in the stream beds of the Warungul circar, in Hyderabad.[6] A similar statement is made by Lieutenant Aytoun with reference to the streams in the Bagulkot taluk of the Belgaum district, where the "black soil also contains the mineral in large proportion."[7] According to the Central Provinces Gazetteer,[8] "titaniferous iron ore is found in the sands of most of the streams" in the Upper Godávari district. Ilmenite is mentioned by Mr. Ball amongst the minerals found in the metamorphic rocks of

[1] Memoirs, G. S. I., Vol. XXI, p. 64.

[2] Records, G. S. I., Vol. XVIII, p. 24. An analysis, by Messrs. Gilchrist and Riley, showed iron 66·85, siliceous matter 2·35, moisture 0·40, and traces of manganese, sulphur, phosphorus, and phosphoric acid. (Journ. Iron and Steel Institute, 1886; 'Iron,' 26th November 1886.)

[3] Records, G. S. I., Vol. XIX, pp. 104, 105, 106, 111.

[4] Memoirs, G. S. I., Vol. XVII, p. 193.

[5] Jour. Roy. As. Soc., Vol. VIII, p. 155; IX, p. 40.

[6] Madras Jour. Lit. and Sci., Vol. XV, p. 223.

[7] Trans. Bom. Geog. Soc., Vol. XI, p. 33.

[8] Page 505.

Mánbhum. Large masses are sometimes to be seen weathered out from the quartz veins, and lying strewn over the surface, in the south-eastern portion of the district.[1]

Iserine.—The iron sand which was smelted formerly at Yeragutty, near Satghur, in Arcot, "is powerfully attracted by the magnet, like iron filings, except a few particles which occur in small blunt grains, and which are probably iserine" according to Dr. Heyne; but he gives no reason for this supposition.

(*c*) Compounds of Protoxides and Sesquioxides—General formula $\dot{R}\dot{R}O_4 = RO.\dot{R}O_3$.

Spinel.—This mineral occurs, apparently in great abundance, in the ruby mines of Upper Burma: the bulk of the 'gem sand' brought from the neighbourhood of Ava is composed of it, and by Tavernier it is called the 'mother of ruby.' It seems most probable that crystalline (dolomitic?) limestone is the ordinary matrix, and that the spinels are found in the three ways already noticed under ruby. Dr. Mason says that "they are seen of all shades; blood-red, the proper spinelle ruby; rose-red, the balas ruby; orange-red, or rubicelle; and violet-coloured or almandine ruby." He also mentions "the dark blue, or blackish varieties of spinelle, called ceylanite or pleonaste," and continues that spinel seems to constitute more than three fourths of the whole mass of gem sand. "A single handful will contain specimens of every shade,—black, blue, violet, scarlet, rose, orange, amber-yellow, wine-yellow, brown, and white. Many retain their original crystalline forms; some have the fundamental form of the species, a perfect octahedron; but many others have some of the secondary forms, among which it is not uncommon to see twin crystals with three re-entering angles."[2]

Specimens of gem sand in the museum (some of which is fine gravel rather than sand) are mainly composed of red and dark-blue spinel. The crystals are octahedrons (fig. 12), very frequently distorted, and often hemitrope (fig. 14). Many have the edges replaced by the faces of the rhombic dodecahedron (fig. 13). One exceptionally large crystal, an inch across, is a double twin—a hemitrope octahedron twinned with a non-hemitrope distorted octahedron (fig. 15). In the British museum there are two specimens, labelled 'Ava;' one is partially polished and measures about $1\frac{3}{4}$ inches $\times$ $1\frac{1}{2}$ $\times$ 1, the other is about $1\frac{1}{4}$ inches in diameter. In the Calcutta collection there are specimens of white crystalline micaceous

[1] Memoirs, G. S. I., Vol. XVIII, p. 103; Manual, Pt. III, p. 323.

[2] Natural Productions of Burma, p. 27.

dolomitic limestone, containing chondrodite and small octahedral crystals of dark-blue spinel, from Mandalay hill, collected by Dr. T. Oldham.[1]

Spinel has been detected by the same geologist in stanniferous and gold-bearing sand obtained by Mr. O'Riley in the Henzai basin, Tavoy district.[2]

There are specimens of white crystalline limestone in the museum, containing chondrodite, mica, and small octahedral crystals of greenish-blue spinel, which were found by M. Schlagintweit near Ambasamoodrum, Tinevelly district, Madras (Lat. 8° 40′, Long. 77° 30′).

According to Captain Newbold, spinel and sapphire "are occasionally found with common corundum in the Salem district, and in the valley of the Cauvery."[3]

The statement that spinel has been obtained at Jagdalak, in Afghánistán,[4] was founded on an erroneous determination of specimens from the locality, which were really rubies.[5]

Picotite has been detected, microscopically, by Colonel McMahon, in a lherzolite from the Puga valley, in Ladákh.[6]

Magnetite occurs in innumerable parts of India, and is abundant in many places. It is found more particularly in the metamorphic rocks, and in the transition series, especially in the former; in both the mineral forms distinct beds. It is also widely diffused as a common constituent of the Deccan trap, whence (as well as from the older rocks) it is washed out, and forms accumulations of magnetic iron sand. The immense deposits of magnetite in the Salem district are especially noteworthy (Pt. III, p. 335).

A very large bed of magnetite has been recently found, by Mr. Foote, in the neighbourhood of the Singareni coal-field, in Hyderabad, and traced for some 3 miles. Bands of hornblendic magnetite schists were also observed in the same neighbourhood.[7]

Crystals, remarkable for their size or otherwise, have not been noticed very frequently. Captain Newbold, however, says that "magnetic iron ore, with polarity, is found at Pakanandoo, in the Salem district, in beautiful octahedral crystals."[8] Such crystals, now in the museum,

[1] Pt. II, p. 708.

[2] Select. Rec. Govt. Bengal, No. VI, p. 38.

[3] Jour. Roy. As. Soc., Vol. VIII, p. 153.

[4] Proc. As. Soc., Bengal, 1880, p. 4.

[5] Page 45.

[6] Records, G. S. I., Vol. XIX, p. 116.

[7] Records, G. S. I., Vol. XVIII, pp. 17, 19. For analyses of magnetite from Landu, in Chaibassa, see Zeitschrift für die gesammten Naturwissenschaften, Halle, Vol. XX, p. 198; and Dana's System of Mineralogy, p. 151. An analysis of the Chanda ore, by Messrs. Gilchrist and Riley, may be found in Jour. Iron and Steel Institute, 1886, and 'Iron,' 26th November 1886. See also paper by C. R. von Schwartz, referred to under braunite.

[8] Jour. Roy. As. Soc., Vol. VIII, p. 155.

range from about one half to nearly one inch in lengths of axes. The altered crystals, from Lower Sind, have already been noticed under the head of martite.[1]

Chromite is known to occur, probably in large quantity, in the Hánle valley, in the district of Rupshu, Káshmir, and has been worked in the Salem district, Madras. The mineral has been reported, although no definite information is available concerning it, from some other parts of Southern India (Pt. III, p. 332). Dr. Balfour states, on the authority of Dr. Clarke, that a good deal of chromite was discovered, by Captain Haldane, in the compound attached to the Residency at Yelwal, in the Ashtagram division of Mysore.[2]

A specimen found in Southern Afghánistán, between the Surkáb valley and Esáb Kuch, was presented to the museum, in 1879, by Surgeon-Major C. F. Oldham.

Some large loose blocks of chromite were discovered by Mr. M. V. Portman, in 1883, at the village of Chakargaon, close to Port Blair, in the Andaman islands: careful search for a deposit *in situ* was made by the writer, but without success. Chromite sand, in the form of minute, well-formed, octahedral crystals, is washed down by some of the streams on Rutland island (south of Port Blair). At one place, where the crystals had been beaten back by the waves, they formed layers more than an inch thick in common sand. The chromite is evidently disseminated through the serpentine, which is abundant on Rutland island.[3]

Chrysoberyl.—There are specimens in the museum of vein granite, from near the village of Rámidi, in the district of Katták, Orissa, containing small crystals of yellowish chrysoberyl, together with moroxite and schorl.[4]

According to Dr. Irvine, "prismatic corundum, or chrysoberyl, is found among the Tora hills near Rájmahál on the Banás, in irregular rolled pieces, small, and generally of a light-green colour: these stones are considered by the natives as emeralds, and pass under the name of 'punna;' but the natives are aware that they are still softer than the real emerald of India (which is generally green-coloured sapphire)."[5] The hills in question, forming a range some 12 miles long of Arvali and Delhi (transition) rocks, are marked 'Toda' on the Indian Atlas (sheet 34). Rájmahál (Lat. 25° 54′, Long. 75° 32′), at the southern end of the range, is a town in Jaipur, Rájputána.

[1] Page 50.
[2] The Iron Ores, &c., of the Madras Presidency, p. 131.
[3] Records, G. S. I., Vol. XVI, p. 204; Vol. XVII, pp. 83, 84.
[4] W. T. Blanford: Memoirs, G. S. I., Vol. I, p. 37.
[5] Topography of Ajmere, p. 160.

It should be mentioned, however, that the Toda hills have been recently examined by Mr. Tellery, who found beryl there (*q. v.*), but who does not mention chrysoberyl. The correctness of Dr. Irvine's statement, therefore, seems open to considerable doubt. Were it not that he uses the term 'prismatic corundum,' an old name for *chrysoberyl*, one might perhaps assume, without further inquiry, that the mineral described under the latter name is really beryl.

Chrysoberyl has been vaguely stated to occur in Burma, but there appears to be no trustworthy information about it.

With reference to *cat's-eye* see p. 69.

(*d*) Deutoxides—General formula $R^{iv}O_2$.

Cassiterite.—"The greatest mineral wealth of the southern portion of the Tenasserim provinces consists in the extensive and valuable deposits of tin ore which they contain. In the granite of the central dividing range, which separates these provinces from Siam, and more especially (so far as my opportunities for examination extended) towards the outer edge of this granite, or near its junction with the highly metamorphosed slates with which it comes into contact, tinstone is an essential ingredient in the mass of the rock, occurring disseminated through the granite in small crystals, similarly arranged to the quartz and felspar of the rock; and in some cases, as at Kahan hill, near Mergui, veins of granite cut through and traverse the more recent (*sic*; older?) rocks, and contain large and abundant crystals of tinstone." [1]

The mineral has been found further north in the Toung-ngu district, and, it is said, in the Shán country south-east of Mandalay. To the south it occurs plentifully in various parts of the Malay peninsula; in all cases, apparently, under similar circumstances, *i.e*, as a constituent of, or intimately associated with, granite.[2] Further south, again, it has been

[1] T. Oldham: Select. Records, Government of India, No. X, p. 56.

[2] In describing the tin-workings at the village of To-lo-lu, 42 miles east of Toungngu, Mr. O'Riley says: "I found that both sides of the water-course consisted of a blue indurated slate, in which lines of quartz of varying dimensions penetrated, and at the junction of the planes of the two rocks the ore (peroxide) formed irregular lodes, the quartz being more or less impregnated with the metal. Specimens of the quartz show long crystals of schorl accompanying those of tin." (Jour. Roy. Geog. Soc., XXXII, 207.) In this connection it may be mentioned that the granitic veins of the Hazáribágh district, in Bengal, which penetrate schistose rocks, and in which traces of tin have been found, vary greatly as to the relative proportions of the constituent minerals; "generally all four (quartz, felspar, mica, and schorl) are present, but in some places the rock consists chiefly of felspar and mica with little quartz; in others it is made up entirely of quartz and mica, and the latter again diminishes in amount until the rock passes into micaceous or into pure vein quartz." (Records, G. S. I., Vol. VII, p. 40.) It may be surmised that the quartz veins described by Mr. O'Riley are equally intimately connected with those of stanniferous granite which (at Kahan hill, and doubtless many other places) traverse the other rocks.

largely worked in the islands of Banca and Billiton, the stanniferous rocks thus stretching more or less continuously, throughout a total length of some 1,800 miles.

Through the degradation of the granite and transport of the *débris* to the low grounds at the foot of the axial range of Tenasserim and the Malay peninsula, widely extended and rich deposits of stream tin have been formed.

Tinstone has been reported from some parts of peninsular India, but nowhere has it as yet been found in any quantity (Pt. III, p. 313).

Rutile.—Mr. G. Young has observed some very minute crystals which he believed to be rutile, in vein quartz traversing mica schist, in the valley of the Gurnai, a tributary of the Beas, in Kulu.

The hill on the west side of the road to Malakheri, a little south of Ulwur, in Rájputána, is composed of quartzite, with some felspathic sandstone. These rocks are intersected by numbers of quartz veins a few inches broad, which, in places, contain white felspar and rutile. The two minerals occur sometimes, but not always, together.[1] Rutile has been observed on the faces of seams dividing the massive corundum of Pipra in South Rewah, and also in microscropic crystals through the latter mineral itself.[2] Minute crystals, which are probably rutile, occur in a similar way through specimens of corundum, now in the museum, from Nongryniew, in the Khási hills.[3]

Acicular crystals of rutile have been observed in amethyst from Tanjore or Coimbatore.[4]

Braunite occurs in large quantity near Vizianagram and Bimlipatam. One of the localities is "within a few miles to the southward of Cheepooroopully, a large village about 20 miles due north of Vizianagram."[5] The ore is said to occur "in huge veins from 3 to 5 feet in thickness amongst primitive granites"[6] (gneiss ?). The Vizianagram ore "presents a highly metallic lustre of a bluish-black colour, interspersed here and there with dull grayish spots, which latter possess the external character of psilomelane. It breaks with difficulty, and when split with a chisel presents an imperfect rhombohedral cleavage. Its specific gravity is 4·50."[7] The mineral from Bimlipatam is "very similar, if not identical to, the foregoing in external characters and chemical characters."

[1] C. A. Hacket: Records, G. S. I., Vol. X, p. 91; Vol. XIII, p. 249.
[2] F. R. Mallet: Records, G. S. I., Vol. V, p. 22; Vol. VI, p. 44.
[3] Records, G. S. I., Vol. XII, p. 172.
[4] Page 66.
[5] E. Balfour: Report on Iron Ores, &c., of Madras Presidency, pp. 238, 240.
[6] Reports by the Juries, Madras Exhibition, 1855.
[7] A. J. Scott, Edin: New Phil. Jour., Vol. LIII (1852), p. 277.

On analysis Dr. Scott obtained—

	Vizianagram.	Bimlipatam.
Manganese, red oxide	73·786	76 177
Oxygen	1·864	·655
Iron, peroxide	12·910	11·720
Lime	..	1·244
Magnesia	2·339	·668
Silica	8·300	9·090
Water	·539	·432
	99·738	99·986

Dr. Scott remarks that the Vizianagram ore agrees most nearly in its composition to that of Damour's marceline, an impure braunite from St. Marcel, in Piedmont. That from Bimlipatam is very similar.

Samples of the same kind of ore are said to have been forwarded from the Kurnool district in Madras, and from Tumkoor in Mysore.[1]

Braunite occurs in large quantity on the south-east side of Munsur great trigonometrical station, a hill 3 miles west of the town of Rámtek, which is about 20 miles north-east of Nágpur. The outcrop is visible for a quarter of a mile, with a thickness of about 10 feet.

The mineral is finely-granular massive, and contains cavities partially filled with rhodonite. An analysis by C. R. von Schwartz [2] gave—

Manganese	54·6
Iron	6 5
Oxygen combined with Mn and Fe	26·5
Calcium carbonate	1·2
Silica and silicates	6·0
Water	5·2
	100·0

And one by the writer [3]—

Manganese sesquioxide	78·64	79·39
Iron sesquioxide	9·78	9·87
Lime	1·20	1·21
Magnesia	trace	trace
Oxygen in excess of that required for Mn_2O_3	1·65	1·67
Silica	6·00	6·06
Phosphoric acid	0·21	0·21
Combined water	2·61	2·63
Hygroscopic water	0·60	...
Disseminated rhodonite	0·35	...
	101·04	101·04

[1] Jury Reports, Madras Exhibition, 1857, p. 2.

[2] Oesterreichische Zeitschrift für Berg-und Hüttenwesen, Vol. XXXIII ; Jour. Iron and Steel Institute, No. 1, 1886, p. 228.

[3] Records, G. S. I., Vol. XII, p. 73.

A deposit of the same class of manganese ore was found, by Dr. W. Blanford, at the village of Kodaigowan (near Khappa), 20 miles due west from Munsur hill.[1]

In 1883 Colonel Bloomfield sent specimens to the museum which proved to be finely-granular braunite, mixed with psilomelane. A sample taken for assay yielded 13·08 per cent. of available oxygen. The ore was found, apparently in large quantity, on a spur of the hills about 2½ miles north-east of Burha, the chief town of the Bálághát district, in the Central Provinces.[2] Colonel Bloomfield had previously found manganese ore in the water-courses near Ambagarh, in the Bhandára district.

It may be noticed that Kodaigowan, Rámtek, Ambagarh, and Burha are nearly in a line, the first and last being about 90 miles apart, and that all the localities are on metamorphic rocks.

Rather more than 60 miles to the west-south-west of Kodaigowan, again, manganese ore of the same outward appearance, and probably braunite, was found some years ago at the village of Peepulcottah, 6 miles south-west of Morsi, in the Amraoti district. It was supposed, however, that the quantity obtained, some 800lb, had been buried at the spot artificially.[3]

Mr. Marcadieu records the discovery, 4 miles north-west of the lines of Dhurmsala, in the Punjab, near an irrigation canal, of a mineral which "approaches by its composition and crystalline form to marcelline." The crystals were octahedral with a square base, and were found in ferruginous and manganiferous siliceous limestone.[4]

Minium.—At Barhamasia, and one or two other spots in Northern Hazáribágh, loose pieces of a dark-red carbonate of lead have been found,[5] and a similar carbonate, but of a brighter colour, and enclosing some metallic lead, has been obtained near Maulmain, in Burma.[6] As the substance, in both cases, contains a mere trace of iron, there can be little doubt that the colour is due to an intimate admixture with minium. Mr. Tween obtained 86·52 per cent. of lead from the Barhamasia ore, which indicates :—

Minium	68·5
Cerussite	31·5
	100·0

Pyrolusite.—"Good but small samples" of "peroxide of manganese"

[1] *Ibid.*
[2] Col. Bloomfield, letter dated 3rd September, 1883.
[3] C. Hordern : letter dated 8th October 1877.
[4] Selections, Punjab Administration, Vol. II, No. VII, p. 4.
[5] F. R. Mallet : Records, Vol. VII, p. 35.
[6] *Ibid.*, Vol. XVI, p. 203,—*vide* "native lead," p. 6.

from Soondoor in Bellary, Roodrar in the Coilcoontlah taluk, Kadapah and from Bimlipatam, are stated to have been sent to the Madras Exhibition of 1857. A sample from the last-mentioned locality, however, examined by Dr. Scott, contained 30 per cent. only of peroxide.[1]

Pyrolusite is said to occur in great abundance in the elevated tract between Bágalkot and Kaládgi, in the Bombay Presidency.[2]

At Gosalpur, in the Jabalpur district, pyrolusite occurs in the rock laterite, in the form of irregular spongy nodules varying in size from a fraction of an inch to several inches in diameter, and averaging perhaps half an inch to one or two inches. These seem to constitute an irregular layer, which is two feet thick where best seen. Above the manganese stratum is ordinary ferruginous laterite, while below it the laterite contains occasional nodules of pyrolusite.[3]

The latter mineral is of interest from its mode of occurrence as a manganese laterite. Large deposits of highly manganiferous hematite exist in the transition rocks near Gosalpur, and elsewhere in the district, and, in the writer's opinion, the manganese laterite has been formed in a manner analogous to that in which he believes the ordinary ferruginous rock may have been produced; that is to say, through the influence of decaying vegetation, of the carbonic acid given off in the process, and of the atmosphere, the higher oxide in the older rocks has been reduced, dissolved, and carried off in solution as carbonate, and re-deposited as the higher oxide, again, in the newer rocks.[4]

The ore, which is believed to occur in considerable quantity, is dark steel-gray, finely crystalline, pyrolusite, mixed with a varying proportion of psilomelane. Some lumps are almost free from the latter mineral; others contain a considerable amount; but, on the whole, the psilomelane is very subordinate to the pyrolusite. The exterior of the lumps and the surfaces of most of the internal cavities are more or less coated by oxide of iron.

A carefully-selected average sample of the ore yielded on analysis:—

Manganese	54·66
Oxygen	31·16
Iron sesquioxide (with trace of alumina)	4·53
Baryta	3·55
Phosphoric acid	·28
Insoluble in hydrochloric acid	2·74
Combined water	2·41
Hygroscopic water	·28
	99·61

[1] Jury Reports, p. 2.
[2] A. Aytoun: Trans. Bom. Geog. Soc., Vol. XI, p. 57.
[3] H. B. Medlicott: Records, Vol. XII, p. 99. F. R. Mallet: *ibid.*, Vol. XVI, p. 116.
[4] *Vide* "Limonite," p. 60.

Another analysis, by Messrs. Gilchrist and Riley,[1] showed :—

Iron	1·87
Manganese	53·22
Siliceous matter	1·93
Sulphur	trace
Phosphoric acid	0·43
Moisture	0·56

Mr. Baden-Powell mentions peroxide of manganese from Jummu, in Káshmir,[2] and Mr. Calvert includes pyrolusite in his list of Kulu minerals.[3]

"Black oxide of manganese" has been reported from several localities, but, as it is doubtful whether the mineral was pyrolusite, it is needless to mention them here. The mineralogical accuracy of some of the notices given above is, perhaps, not altogether beyond doubt.

B.—Hydrous Oxides.

Turgite.—Specimens of this mineral, in association with limonite, have been obtained by Dr. King from the neighbourhood of Juggiapett in the Kistna district.[4] It is partly granular massive, partly fibrous and sub-columnar, with a dark red to iron-black colour, and red streak. The fibrous kind yielded :—

Ferric oxide	93·10
Water	4·65
Insoluble	2·09
	99·84

The mineral decrepitates with violence when heated in a closed tube or crucible. It is not known whether it occurs in large quantity or not.

Manganite.—The only Indian specimen of this mineral, that the writer is acquainted with, is one received some years ago from the Political Agent at Gwalior, and presumably obtained from that neighbourhood.

Limonite is, like the anhydrous oxides of iron, extremely abundant in India. It sometimes occurs in the form of beds in the older rocks, many of which are perhaps due to superficial alteration of hematite or magnetite. It is also found in connection with faults. The ironstone shale group of the Gondwána series affords large quantities of the mineral in an impure state, owing to the alteration of clay-ironstone near the surface. But by far the most extensive deposits are to be found in the laterite, which, especially in connection with the Deccan trap, covers such large areas. As a general rule, the rock contains some 25 to 60 per cent.

[1] Jour. Iron and Steel Institute, 1886; 'Iron,' 26th November 1886, p. 476.
[2] Punjab Products, Vol. I, p. 25.
[3] Kulu: its beauties, &c., p. 72.
[4] Records, G. S. I., Vol. XIV, p. 304.

of hydrous peroxide only; but near the base of the deposit, in some districts, there are beds of pisolitic limonite containing but little impurity. (Pt. I, p. 348; Pt. III, p. 335.)

In the north-eastern part of Jabalpur, for instance, such beds occur, some of which are two or three feet thick and of wide lateral extension. Several analyses have been made, of which the following may be quoted as giving the composition of the purest ore : [1]—

Ferric oxide	81·20	82·18
Loss on ignition	13·42	13·89
Phosphoric acid	1·41	0·76
Sulphuric acid	trace	trace
Sulphur	trace	traces
Ignited insoluble residue	1·29	1·57
Alumina, lime, and undetermined	2·68	1·60
	100·00	100·00

The difficult question of the origin of laterite has been discussed in detail by Mr. Blanford in the first part of the present work.[2] Since that part was written it has been suggested by the present writer[3] that of the three forms of laterite which appear to be generally recognised *i.e.*—

1st—Laterite due to deposition and excluding the third form,
2nd—Laterite due to the alteration of other rocks *in situ*,
3rd—Detrital laterite due to the denudation and re-deposition of the first or second form,

the first may be a chemical deposit, analogous to bog-iron ore, and due to the leaching out of iron from ferruginous rocks like the Deccan trap, and its subsequent re-deposition in a more concentrated form. Through the agency of decaying vegetation, and the carbonic acid produced by its decomposition, the iron may have been reduced to the state of carbonate, and carried off in solution, to be subsequently again peroxidized by atmospheric action, and re-deposited. As this, however, is a geological rather than a mineralogical question, its full discussion here would perhaps be rather out of place.

Beauxite.—Specimens of a mineral which occurs "in veins underneath the (eocene) coal strata" at Chitteedand, in the Salt range, and which, from the result of a qualitative analysis, he believes to be beauxite,

[1] Records, G. S. I., Vol. XVI, pp. 105, 109. For recent analyses of these ores, and of those from Barákar, in the Rániganj coal-field, by C. R. von Schwartz, see papers quoted under braunite. p. 56. Others, by Messrs. Gilchrist and Riley, may be found in Jour. Iron and Steel Institute, 1886 (abstracted in 'Iron,' 26th Nov. 1886).

[2] Page 348.

[3] Records, G. S. I., Vol. XIV, p. 139; Vol. XVI, p. 116.

have been presented to the museum by Dr. H. Warth.[1] The mineral is pure white, has a minutely crystalline structure, and, judging from the specimens sent, would appear to occur in seams from a quarter to half an inch thick.

Psilomelane is of not infrequent occurrence, more usually in association with, and subordinate to, braunite or pyrolusite. It has been noticed in the following localities.

About 6 miles to the northward of Vizianagram, on the road to Pálkonda. Although the mineral has not been traced *in situ*, it has been found loose in such quantity as to have been used for road metal. Two samples on assay gave 67·7 and 53·5 per cent. of available peroxide.[2]

In association with the braunite of Vizianagram.[3]

"In great abundance" in the elevated tract between Bágalkot and Kaládgi, in the Bombay presidency, where it is said to occur with pyrolusite.[4]

Around Malágarh hill, in the Wun district, Berár, where a very impure form of the mineral occurs in botryoidal masses in the red clays of the Kámthi series.[5]

In association with the braunite of Bálaghát.[6]

At Gosalpur, in the Jabalpur district, where it is found in manganiferous micaceous hematite, occurring as linings to small cavities in the rock, and in irregular segregations and masses, some of which contain some cubic feet of mineral. The ore appears to be most abundant where the hematite has been crushed and re-cemented, psilomelane being the cementing material. A sample yielded 83·20 per cent. of available peroxide. The mineral has been found under similar circumstances at Kuthola, 6 miles north-north-east of Gosalpur.[7]

Also occurs at Gosalpur in association with pyrolusite.[8]

Near Bási (west of Tiki), in the South Rewah coal-field, where it has been found by Mr. T. H. Hughes in nodules through red (Jabalpur?) clay.

There are specimens in the museum of stalactitic psilomelane, with limonite, from Ajmere, and others, of psilomelane on the same ore of iron, collected by Mr. C. A. Hacket at Gangar north of Neemuch.

Dr. J. Anderson has contributed specimens of impure manganese oxide, chiefly psilomelane, from Gna islet, Padau bay, King island, Mergui archipelago, and there are also in the museum specimens of

[1] Records, G. S. I., Vol. XIX, p. 166.
[2] W. King: Records, G. S. I., Vol. XIX, p. 155.
[3] Page 55.
[4] A. Aytoun: Trans. Bomb. Geog. Soc., Vol. XI, p. 57.
[5] T. W. H. Hughes: Records, G. S. I., Vol. VII, p. 125.
[6] Page 57.
[7] F. R. Mallet: Records, G. S. I., Vol. XVI, p. 102.
[8] Page 58.

psilomelane, with limonite, from Mergui, and of ferruginous oxide of manganese, including some psilomelane, from Tavoy.

Wad has been noticed in connection with the psilomelane on the Pálkonda road, near Vizianagram,[1] and in thin films coating the rocks in the neighbourhood of Yetagon, a few miles above Yembaing, a large village on the Salween, about 70 or 80 miles from Maulmain.[2]

In 1841 Captain Tremenheere reported the discovery of wad, in large quantities, in the basin of the great Tenasserim river, but specimens sent to Mr. Piddington were found by him to contain no manganese, and to be almost wholly carbonaceous.[3]

2.—Oxides of elements of the Arsenic and Sulphur groups.

Valentinite. (?) —According to Captain Hutton, stibnite occurs abundantly in some of the mountains to the northward of Killa Abdoollah in Pishin, on the Afghán frontier, north of Quetta, and is accompanied by "the oxide or white antimony."[4]

Kermesite and cervantite are found in connection with the immense lodes of stibnite at Shigri, in Lahol, North-Western Himalayas.[5] There are specimens of both oxides, presented by Mr. Calvert, in the museum.

Cervantite occurs at Shigri, as mentioned under the preceding mineral. The stibnite deposits near Maulmain, described by Mr. Criper,[6] are sometimes altered near the surface into cervantite. The latter mineral, owing to its earthy appearance, was not recognised as an ore of antimony by the Burmese, until it was pointed out to them by the writer quoted.

3.—Oxides of the Carbon-Silicon group.

Quartz.—*Rock Crystal.*—In the Tanjore district, pebbles, sufficiently clear for cutting into spectacle lenses, occur in the Cuddalore (tertiary) grits or conglomerates near Vellum, and are found loose in the beds of the streams running off the grit plateau. They, and the smoky quartz and cairngorms found with them, are supposed to have been derived, originally, from quartz veins in the metamorphic rocks.[7]

In the bed of the Godávari, west of Rajahmundri, large crystals have been found. Some that Captain Campbell saw were nearly 4 inches in diameter.[8]

[1] Page 61.
[2] R. Romanis' Report on Minerals of Tenasserim, 28th July 1885.
[3] *Vide* Tremenheerite, p. 10.
[4] Calcutta Jour. Nat. Hist., Vol. VI, p. 599.
[5] J. Calvert: Kulu: its beauties, &c., p. 50.
[6] Page 13.
[7] W. King and R. B. Foote: Memoirs, G. S. I., Vol. IV, pp. 258, 370.
[8] Calcutta Jour. Nat. Hist., Vol. II, p. 282.

According to Captain Newbold, the quartz, which forms a constituent of the granite dyke in which the beryl mine at Paddioor (in Coimbatore) was sunk, is sometimes regularly crystallized, and one crystal was extracted which measured 27½ inches in length and 15 in diameter.[1] Dr. Buchanan says that between Pogolur and Karur "the soil is generally poor, with many projecting rocks, especially of pure white quartz, among which are found irregular masses perfectly pellucid." [2]

In Mysore "milky quartz is segregated into large beds (reefs?) forming chains of hills, usually containing nests and seams of iron ore, rock-crystal, and crystals of amethystine quartz." Quartz in large crystals is also said to form a constituent of coarse granite.[3]

In parts of Hyderabad rock crystal is common, according to Dr. Walker.[4]

In the Central Provinces "remarkably fine rock-crystals occur in some abundance near Bijkomar, to the south of Bolangir (Sambalpur district). They appear to occur in a nest in vein-quartz." [5] Specimens in the museum, brought by Mr. Ball, range up to 8 and 9 inches in length, with a diameter of 2 or 3. Very pure rock-crystal is found in the Bhadráchallam and Rakapalli taluks, in the Upper Godávari district.[6]

Over the immense area covered by the Deccan trap, which comprises large portions of the Bombay presidency, Berár, Central India, and part of the Central Provinces, crystallized quartz is common in the form of geodes. Very frequently these have a chalcedonic shell, from the interior of which the crystals have grown, but sometimes the geode is formed wholly of crystalline quartz. Some contain large drusy cavities in the interior; others are nearly, or completely, filled with crystals, converging to the centre. More often than not, perhaps, the quartz is scarcely sufficiently clear to be called rock-crystal. "It but seldom occurs in crystals which exceed an inch in diameter, and the larger crystals are not often transparent. The form known as trihedral quartz, in which the terminal pyramid of each quartz crystal consists of three planes instead of six (fig. 16), or in which three planes are very much more developed than the other three, is of common occurrence." [7] Specimens in the museum, from the Thul ghát, show the three terminal planes only, the prismatic planes being buried between the closely-packed crystals.

The distribution of quartz, and of the secondary minerals generally,

[1] Madras Jour. Lit. & Sci., Vol. XII, p. 172.
[2] Journey through Mysore, &c., Vol. II, p. 299.
[3] Mysore Gazetteer, Vol. I, pp. 20, 21.
[4] Madras Jour. Lit. & Sci., Vol. XVI, p. 187.
[5] V. Ball: Records, G. S. I., Vol. X, p. 183.
[6] Central Provinces Gazetteer, p. 506.
[7] W. T. Blanford, Pt. I, p. 305.

is by no means uniform over the trappean area. "In one part quartz predominates, in another chalcedony; and these are more or less associated with jaspers, agates, hornstones, heliotrope, and semi-opal or cacholong. In other places particular members of the zeolite family prevail, nearly to the exclusion of the siliceous class; and elsewhere there is a diminution of minerals amounting almost to privation." [1]

At Tankára, 24 miles north of Rájkot, in Káthiawár, "crystal, a clear transparent stone resembling glass in appearance," is said to occur in masses under the surface of the soil, from 1 to 20lb in weight." [2] As Tankára is on Deccan trap, where large crystals are not known to occur, probably masses of aggregated crystals are meant.

Between Baroda and Oodeypore Mr. Hardie noticed "immense beds of quartz-rock," in some of which "numerous imbedded masses of a nearly transparent quartz, forming a coarse rock-crystal, occur; indeed, almost the entire of some of the beds exists in this last form." [3] The same author mentions having seen "some very beautiful specimens of rock-crystal" from Meywar, in Rájputána.[4]

According to Captain Dangerfield, rock-crystal is abundant in part of the hill range which runs north and south past (west of) Oodeypore; images, &c., of that material being exported thence, as well as from Jaipur, to neighbouring parts of India.[5]

"Fine specimens of rock-crystal are occasionally picked up" on Mount Abu.[6]

We have been informed by Colonel Muir, the Political Agent, that "crystals, sometimes of a large size," are found at Karaola and Hataona, in Tonk. Specimens sent to the museum were small and poor.

Mr. Tellery, manager of the State Garnet Works, has recently made experimental diggings at Nawai, near the village of Hustal, in Jaipur, but the crystals found were too small to have any marketable value, and the quarries were abandoned.[7]

In the Punjab, rock-crystal has been obtained from pits 2 or 3 miles to the south-west of Aurangpur, a village about 15 miles south of Delhi. "The crystal does not occur in its primitive position, but in a secondary deposit of siliceous breccia very highly impregnated with iron. Each crystal is encased in a sheath of hematite." Lower down the matrix becomes less ferruginous, and then purely argillaceous, and

[1] W. H. Sykes: Trans. Geol. Soc., 2nd Ser., Vol. IV, p. 424.

[2] Select. Rec. Govt., Bombay, No. IV, p. 29. In the original, Tankára is said to be 12 miles north of Rájkot, but it is 24 on the Indian Atlas.

[3] Asiatic Researches, Vol. XVIII, Pt. I, p. 93; Pt. II, p. 63.

[4] Edin. New Phil. Jour., 1829, p. 335.

[5] Malcolm's Central India, Vol. II, p. 343.

[6] Rájputána Gazetteer, Vol. III, p. 93.

[7] Report on Jaipur Garnet Works for 1885, p. 4.

the largest and purest crystals are said to be found in this white clay.[1] The rock in which the breccia occurs is Arvali (transition) quartzite.

Doubly-terminated crystals of quartz, "either transparent, reddish, or more opaque, are found in quantities in the gypsum of Mári" on the Indus, at the western end of the Salt range. Similar crystals are found at Kálabágh, on the other side of the river, and at Katha, Sardi, and Kusak, in the Salt range.[2] According to Dr. Jameson, the colour of the crystals "varies in general with the rock; the most beautiful varieties are the rose red, but they occur also white, gray, brick-red, black, &c., varying from transparent on the edges to semi-transparent, translucent, and opaque; in form generally the six-sided prism terminated by the double six-sided pyramid, but with numerous modifications[3] of the terminal planes, and sometimes the lateral planes are wanting altogether, when we have the double six-sided pyramid. In other crystals one of the lateral planes will be large at the expense of all the other five, which are only represented in miniature, but the forms[3] are too much varied to attempt to notice them all. In size they vary from that of millet seed to two or three inches. The resplendent appearance presented by the gypsum when the sun is shining, produced by these imbedded crystals, is very striking. * * * The crystals are of contemporaneous formation with the gypsum, and probably have been formed by segregation of silica from that rock. In the rock-salt, though much more rarely, crystals are found imbedded."[4] With reference to the last sentence, Mr. Wynne remarks that he has never observed rock-crystals in the salt, or known them to have been observed.[5]

Figure 17 illustrates the commonest type of Salt range crystal amongst those in the museum. In other crystals the pyramidal planes are predominant (fig. 18), and the double pyramid without prismatic planes (fig. 19) is also met with, as well as crystals like those represented by figs. 20 and 21. Others are distorted from the enlargement of certain planes.

In Káshmir, rock-crystal is said to be found in crystals of considerable size and purity in the tertiaries on the route from Leh to Skiu, in the neighbourhood of the Rambak-lá (about 15 miles south-west of

[1] Dr. Thomson, quoted in B. H. Powell's Hand-Book of Punjab Economic Products, p. 47.

[2] *Op. cit.*, pp. 41, 48, 59. A. B. Wynne: Memoirs, G. S. I., Vol. XIV, p. 300.

[3] Dr. Jameson appears to use the terms 'modification' and 'form' in reference, merely, to the varying relative sizes of similar planes, due to distortion. A large number of specimens in the Museum have only the faces ∞P. R.—R. Some of them are very symmetrical, while others are distorted.

[4] Jour. As. Soc., Bengal, Vol. XII, p. 206.

[5] Memoirs, G. S. I., Vol. XIV, pp. 77, 300.

Leh). Mr. Lydekker has been shown good specimens obtained from the metamorphics of the Pádar district, on the Upper Chináb. Large crystals occur in the metamorphics of part of the Ladákh range, but they are almost always opaque.[1] "Ordinary quartz-crystals, some of them very large," are said by Mr. G. Young to have been found in association with the sapphires of the Zánskar range.[2]

In the trappean rocks of the Rájmahál hills "agate and quartz occur in great beauty and variety, of every size, from a mere point to some feet across; forming a thin coating on the surface of the vesicle, or partially or entirely filling the cavity. In the majority of cases, these cavities have a thin coating of natrolite immediately adjoining the trap, inside which the agates have been formed. The quartz, when it occurs, is generally the innermost, or last deposited mineral. There has often been a repetition of these layers of agate and quartz. In colour they are generally white, or smoke-coloured; occasionally the agate layers have a red tint, while the quartz crystals are sometimes, though rarely, of a beautiful amethystine tint (Burhait). The agate occurs in botryoidal, reniform, and mammillated groups, and some very beautiful specimens have occurred."[3]

"Small crystals of quartz are common in Tenasserim, and large specimens of rock-crystal are sometimes brought from the Siamese frontier."[4] Small, but limpid, rock-crystals have been found in the seams of a cherty rock associated with crystalline (tertiary ?) limestone, in the island of Rámri (Arakan);[5] and "fine crystals of quartz" occur, in connection with quartz-veins, on the island of Bompoka, in the Nicobars.[6]

Milky quartz is of very common occurrence in the form of quartz-veins traversing the crystalline rocks of India. Crystals of the mineral sometimes occur in connection with the veins, as at Bijkomar, in Sambalpur, where they have been found with rock crystals.[7] The latter, indeed, are generally milky towards the base. A crystal of the former kind, obtained by Mr. Ball, measures 12 × 4 inches.

Crystallized milky quartz is also common in geodes in the Deccan and Rájmahál traps, there being every gradation from such to rock-crystal.[8]

Amethyst is said to occur with the rock-crystals found near Vellum, in Tanjore.[9] Amongst other specimens presented to the museum, as

[1] R. Lydekker: Memoirs, G. S. I., Vol. XXII, p. 340.
[2] American Jour. Sci., 3rd Ser., Vol. XXVI, p. 339.
[3] T. Oldham: Jour. As. Soc. Bengal, Vol. XXIII, p. 271.
[4] F. Mason: Natural Productions of Burma, p. 19.
[5] Records, G. S. I., Vol. XI, pp. 192, 222.
[6] H. Rink: Select. Rec. Govt. India, No. LXXVII, p. 133.
[7] Page 63.
[8] Page 63.
[9] Page 62.

'Vellum stones,' was "a crystal of amethyst (a six-sided prism, with terminal pyramids) in which, radiating from the corresponding faces of an internal pyramid, was a brush of small acicular crystals of rutile. The crystal, which was rather broken at one end, measured one inch in length by 3·5 (*sic.* ·35 ?) in diameter."[1] According to Mr. H. F. Blanford, however, the amethysts are all brought to Vellum from Kangiam, in Coimbatore,[2] from which locality specimens now in the museum are said to have come.

A lead-bearing vein, in crystalline rock, at Coilcontla, Kurnool, described by Mr. Wall, "generally is well defined by its walls of clear amethyst quartz."[3] Amethystine quartz has also been noticed in Mysore.[4] According to Dr. Walker, amethyst "is found in the quartz-veins of the granite, and is by no means rare, in every part of the Hyderabad soubah, and is cut into ring stones, &c."[5] Dr. Heyne noticed large crystals of amethyst, striated, and not of the finest colour, in the same region.[6] According to Dr. Balfour, "beautiful amethyst crystals occur in dykes of quartz near Bowenpilly, at Secunderabad."[7] The same mineral, together with rock-crystal, &c., is found in the bed of the Godávari river.[8]

Amethyst occurs, in drusy geodes, in the Deccan trap, although comparatively rarely.[9] Generally (according to Colonel Sykes, always) there is a chalcedonic shell, from the interior of which the amethyst crystals spring. Very often the lower part of these are of milky quartz, the pyramidal and neighbouring part being amethystine. The geodes of the Rájmahál trap also include amethystine quartz, although but rarely.[10]

Mr. Hardie mentions having seen "some crystals of amethyst, of no great value," from Meywar.[11] At the village of Rondel, near Samote, in Jaipur, where amethysts were said to occur, Mr. Tellery has recently made experimental diggings, but the crystals found were either too small, or too inferior, for use.[12]

A few crystals of amethyst have been found, according to Mr.

[1] W. King and R. B. Foote : Memoirs, G. S. I., Vol. IV, p. 371. The specimen was lost at sea before reaching Calcutta.

[2] *Ibid.*, p. 217.

[3] Madras Jour. Lit. & Sci., Vol. XX, p. 291.

[4] Page 63.

[5] Madras Jour. Lit. & Sci., Vol. XVI, p. 186.

[6] Tracts on India, p. 265.

[7] Cyclopædia of India, Vol. I, p. 91.

[8] Oriental Repertory, Vol. II, p. 472.

[9] W. T. Blanford : Pt. I, p. 305. W. H. Sykes : Trans. Geol. Soc., 2nd Series, Vol. IV, p. 424.

[10] Page 66.

[11] Edin. New Phil. Jour., 1829, p. 335.

[12] Annual Report on Jaipur Garnet Works for 1885, p. 4.

Young, in association with the sapphires of the Zánskar range, in Káshmir.[1]

"Pebbles of amethyst, or violet quartz, are brought from the rivers of Burma, where they are regarded as a variety of the sapphire,"[2] Mr. Mason says. Further on, he alludes to the occurrence of "violet sapphire, or oriental amethyst," thus clearly distinguishing between the two stones.

Rose quartz is met with occasionally in portions of the quartz-veins which traverse the crystalline rocks of India. As cases in point, specimens now in the museum from the Bankura and Hazáribágh districts, in Bengal, may be mentioned. Dr. Walker says that such quartz is common in Hyderabad,[3] and Mr. Hardie describes a stratified quartzite, some parts of which had a slight rose tinge, between Sagwára and Jariána, in Dungarpur, Rájputána.[4] According to Dr. Thomson, rose quartz is one of the varieties of the mineral which are found in the trap geodes in the Bombay islands,[5] and it has been noticed under similar circumstances in the Deccan.[6]

False topaz, or yellow quartz.—"Very beautiful golden yellow transparent quartz" is said to have been found in the Nellore district,[7] and the same variety also occurs near Vellum, in Tanjore, with the rock-crystals already noticed.[8] "Dull specimens of yellow quartz, or citrine," have been met with, by Dr. Mason, on the Tenasserim, but they are not common.[9]

Smoky quartz is found with the rock-crystals of Vellum,[10] and, like the crystal and false topaz, is cut into ornaments by the lapidaries there. Rather large crystals have been obtained from Bolangir, in Sambalpur, where they occur with rock-crystals.[11] One in the museum is 7 inches long. Dr. M'Celland states that "smoky quartz is found in large quantities on the surface of the alluvium near Panch Pahár," in the Sánthál pargannahs, but has not been observed *in situ*.[12] Some of the quartz-crystals occurring in the geodes of the Rájmahál trap are smoky, as already noticed.[13]

[1] American Jour. Sci., 3rd Series, Vol. XXVI, p. 339.
[2] Natural Productions of Burma, p. 20.
[3] Madras Jour. Lit. & Sci., Vol. XVI, p. 187.
[4] Asiatic Researches, Vol. XVIII, p. 93.
[5] Madras Jour. Lit. & Sci., Vol. V, p. 161.
[6] Newbold: Jour. Roy. As. Soc., Vol. IX, p. 37.
[7] Indian Jour. Arts & Sci., Pt. VIII, p. 578.
[8] Page 62.
[9] Natural Productions of Burma, p. 20.
[10] Page 62.
[11] Page 63.
[12] Report Geol. Sur. for 1848-49, p. 68.
[13] Page 66.

Cat's-eye, from the coast of Malabar, has been described and analysed by Klaproth. The largest of the specimens in his possession, which were uncut, measured $1 \times \frac{3}{4} \times \frac{3}{4}$ inches. Its colour, on the cross fracture, was a brown-red, with a lighter tinge on the longitudinal; the specific gravity was 2·625.[1] The portion of the mineral analysed yielded—

Silica	94·50
Alumina	2·00
Oxide of iron	·25
Lime	1·50
	98·25

Cut specimens of quartz cat's-eye, said to be from Malabar, in the museum, are of a light greenish-gray colour, and indifferent quality, but they may not be fairly representative.

Dr. Balfour states that the cat's-eye is obtained from Quilon and Cochin, and in the neighbourhood of Madras.[2]

According to information received by Dr. Heyne, cat's-eyes are found in the bed of the Kistna, in the neighbourhood of the Palnád[3] (north-west part of Guntoor).

Cat's-eye, "the principal colour of which is gray, presenting many varieties, usually translucent, is found on the Bowa Goree and Bowa Abbas hills (near Ratanpur, in the state of Rajipla, Bombay), or at their base, and in the bed of the river formed by the rains between the hills, which is dry in the month of October. It occurs in blunt-edged and rolled pieces. The pebbles are of various shapes, and small sizes, not exceeding 2 oz. in weight. *Roree* or *Lussunia*, a yellow pebble, semi-transparent, is found scantily with the cat's-eye. It receives a very fine polish, is much esteemed, and is usually cut for ring stones."[4] *Lahasaniá* is the Hindi name given to cat's-eyes that "are green or yellow, clear, and have reflecting powers like those of the looking-glass."[5]

Dr. Mason states that cat's-eyes are brought from Burma, but that those seen in the Maulmain market are not much valued, ten rupees being the highest price given for the best.[6]

It is to be noted that, except with reference to that from Malabár, in no case is it stated whether quartz or chrysoberyl cat's-eye is meant. As the matrix of chrysoberyl is usually granitic or metamorphic rock, while that at Ratanpur is trappean, it is highly improbable that

[1] Analytical Essays, p. 78.

[2] Encyclopædia, Vol. I, p. 607.

[3] Tracts on India, p. 235.

[4] A. Summers: Select. Rec. Govt. Bombay, new Series, No. IV, p. 31.

[5] Raja Sourindro Mohun Tagore: Mani-Málá, Pt. II, p. 867. Mr. Prinsep suggests that *lahsúnia* is the star sapphire (Jour. As. Soc., Bengal, Vol. I, p. 356).

[6] Natural Productions of Burma, p. 20.

the cat's-eye there is chrysoberyl. Indeed, as one author mentions the "cat's-eye called *cheshamdár* or *dola*," and on the same page says "the common agate is of two kinds, a white half-clear stone called *dola* or *cheshamdár*,"[1] &c., it may well be doubted whether the stone called cat's-eye by Mr. Summers, and others, is even true quartz cat's eye.

Prase has been observed in pegmatite, in the Nilgiri hills.[2] Massive and crystallized "leek-green" prase was noticed, by Dr. Heyne, in some large specimens from near Hyderabad, associated with quartz, amethyst, pyrites, and calcspar.[3] In Tenasserim "green quartz, or prase, is sometimes found in the form of pebbles in the mountain streams, but it is not very abundant."[4]

Captain Franklin states that the diamond-bearing conglomerate in some of the mines near Panna, in Bundelkhand, contains, with other pebbles, those of green quartz, and that it is considered a good sign when the latter are abundant.[5]

Avanturine.—Specimens of an extremely handsome bright-green avanturine are included in the museum collections. One of these is a block measuring $7 \times 3 \times 2$ inches. The avanturine character is due, in part at least, to minute scales of silvery mica bespangling the massive translucent quartz. The specimens, presented by Colonel Guthrie, are said to have come from the Bellary district, but unfortunately the exact locality is unknown.

Chalcedony and *agate* occur in immense profusion in the Deccan traps, and are prominently alluded to by almost every writer on those rocks. "Chalcedonies and agates occur in the amygdaloidal cavities of the trap, from the size of a pea to that of a six-pound shot, or larger. They are often found in the form of geodes, filled, or partially filled, with crystals of quartz; sometimes amethystine, in the centre of which is often seen a crystal of calcspar. The exterior shape of these masses of chalcedony and agate is extremely regular (*sic.* irregular?); sometimes spherical, but more commonly compressed and irregular; generally botryoidal, or mammillary, or stalactiform. Sometimes the chalcedony is so perforated by a number of small circular cavities as to resemble a bubbled mass of white lava."[6] In some parts of the country, owing to the decomposition of the trap, the surface is strewn with geodes, and nodules, some of which are one or two feet in diameter. In some cases these minerals occur in flat plates, which appear to have been formed in cracks.[7] Through the great

[1] Bombay Gazetteer, Vol. VI, p. 199.
[2] H. Congreve: Madras Jour. Lit. & Sci., Vol. XXII, p. 237.
[3] Tracts on India, p. 265.
[4] F. Mason: Natural Productions of Burma, p. 20.
[5] Asiatic Researches, Vol. XVIII, Pt. I, p. 106.
[6] Newbold: Jour. Roy. As. Soc., Vol. IX, p. 38.
[7] W. T. Blanford, Pt. I, p. 305.

denudation, again, which the traps have undergone, extensive beds of tertiary agate-gravel have been formed, and agates have been swept down by the rivers and are now collected far away from the trappean area. A considerable trade exists in the collection, treatment, and cutting of the different varieties, the chief centre of which is at Cambay, although such lapidary work is also carried on at Jabalpur and Bánda. The different stones used, which are chiefly brought from near Rájkot, in Káthiawár, and Rájpipla, in Rewa Kántha, and the methods employed at Cambay, have been described by several writers. One of the best accounts is quoted *in extenso* in Part III of the present work (p. 507).

Chalcedony and agate are also abundant in the traps of the Rájmahál hills.[1] Some of the specimens now in the museum show a double mode of growth, the exterior having been formed in concentric layers, and the interior in parallel ones. In others, again, the exterior concentric shell of agate is lined with crystals of quartz, within which are further concentric layers of agate, and finally a centre of parallel ones.

The localities where chalcedony, &c., have been reported to occur beyond the areas of the above trappean rocks, and the rivers draining from them, do not seem to be numerous. "Chalcedony of white, yellow, green, and blue colours, stalactitic, dendritic, botryoidal, and massive in shape, lining the geodes of cellular ferruginous quartz," is stated to occur in the Nilgiri hills.[2] The same mineral has been reported from the Bangalore district.[3] "Near the city of Biana, which lies about 50 miles west-south-west from Agra, there occurs a series of alternations of a ferruginous quartz rock, with a peculiar conglomerate, containing imbedded agates, agate-jaspers, and similar minerals, with adularia, &c. The cementing medium is exceedingly hard and compact, and is itself of the nature of agate. These rocks occupy the rugged termination of a hill range, which stretches from this point in the direction of Ajmere."[4] According to Dr. Mason, "chalcedony, both white and yellow, has been discovered at Moopoon, near Maulmain, and is very abundant in Burma; * * * agate is found at Moopoon, and, the natives say, at Mergui also."[5] Mr. Theobald, however, remarks that both statements require confirmation.[6]

Although some of the succeeding stones—those immediately following—are merely varieties of the above, it may be desirable to notice them separately.

Agate-jasper is common in the Deccan trap. Captain Newbold

[1] Page 66.
[2] H. Congreve: Madras Jour. Lit. & Sci., Vol. XXII, p. 249.
[3] Mysore and Coorg Gazetteer, Vol. II, p. 2.
[4] J. Hardie: Edin. New Phil. Jour., Vol. XIV (1833), p. 79.
[5] Natural Productions of Burma, pp. 21, 22.
[6] *Ibid.*, 2nd edit., p. 13.

mentions it as being found in the beds of the Kistna, Godávari, and Bhima rivers, and in the Rájpipla hills,[1] and there are handsome specimens from the Narbada valley, and from Bánda, in the museum. It may be noted here that the agates, &c., cut at Bánda, are brought down by the river Kén from the trappean area. The occurrence of agate-jasper near Biána, in Bhurtpore, has been alluded to above, and Mr. Hardie mentions having observed it as the cementing material of a very beautiful quartz conglomerate, at the village of Sawah, 14 miles north of Neemuch. The same mineral was also noticed near the fort of Buneerah, about 9 miles from Oodeypore.[2] Dr. Irvine says that fragments are brought down by the Banás and other rivers, in Rájputána.

Carnelian is obtained in large quantities, from mines in tertiary agate gravels, near Ratanpur, a village in the state of Rájpipla, 13 miles east of Broach. A full account of the methods of mining and treating the stones may be found in Pt. III, p. 507. The pebbles, which are originally derived from the Deccan traps, and are of different sizes up to a pound in weight, and chiefly of uneven form and surface, "are cloudy, of various shades of brown, and others of different tints of yellow, in the natural state. After exposure to the sun, and baking, these assume other tints as follows: light brown becomes white, *dhola*; pale yellow, rose-coloured, or *gulabi*; deep yellow, red, or *lall*; a mixture of cloudy brown and yellow becomes white and red, named *ubluckee*; another shade of yellow turns pinkish purple, named *nafarmani*; and brown becomes a darker shade, named *emni*." [3]

Carnelian has also been reported from other parts of the Deccan trap area. The accounts, however, do not state what the natural colour of the stone is, or whether it is artificially changed or not. Captain Newbold mentions that it is found in the beds of the Godávari, Kistna, and Bhima rivers,[4] and Dr. Heyne near Hyderabad.[5] It is said to occur, although but rarely, in the neighbourhood of Bombay.[6]

According to Dr. Irvine, pebbles of inferior carnelian are found in some of the streams of Rájputána.[7] "At Chumpar Pahar, about 6 miles north-east of Dubrajpore, in the Rájmahál hills, carnelian and topaz occur in drusal cavities of trap." [8] Probably the author meant yellow quartz by topaz.

Some of the Indian carnelian is of the variety known as *sard*, a large mass of which is exhibited in the British museum collection.

[1] Jour. Roy. As. Soc., Vol. IX, p. 37.
[2] Edin. New Phil. Jour. Vol. VII (1829), pp. 117, 119; Vol. XIV (1833), pp. 79, 279.
[3] A. Summers: Select. Rec. Govt. Bombay, No. IV, p. 30.
[4] Jour. Roy. As. Soc., Vol. IX, p. 37.
[5] Tracts on India, p. 264.
[6] R. Thomson: Madras Jour. Lit. & Sci., Vol. V, p. 161.
[7] Topography of Ajmere, p. 161.
[8] J. M'Clelland: Report of Geological Survey of India for 1848-49.

Moss-agate is not uncommon in the Deccan trap. It is found near Tankára, in the state of Morvi, Káthiawár, and, about 3 miles from the same village, at Bud Kotra, "about 2 feet under the surface of the soil, in massive layers, cracked, and weighing from ½ to 30 or 40lb." [1] "At Khijaria, a village 2½ miles west of Tankára, some moss-agate, occurring as a large irregular vein in decomposed amygdaloidal trap, has been worked in a desultory way by the villagers for a number of years." [2] Specimens brought by Mr. Fedden are of very translucent gray, or of white, chalcedony, through which a green mineral, apparently glauconite, is interspersed, partly in moss-like forms. Some specimens show reddish-brown delineations mixed with the green, due to oxide of iron.

Moss-agate is also found in Rájpipla; in the beds of the Godávari, Kistna, and Bhima rivers,[3] near Hyderabad,[4] and at Bánda.[5] Specimens in the museum, from the last locality, are not unlike those from Morvi. Small moss-agates are picked up, it is said, in the Banás river, in Rájputána.[6]

Mocha stone is also found in the Deccan trap. A remarkably fine series of cut specimens, bought at Jabalpur, and obtained, perhaps, from the Narbada, is now in the museum. "Mocha stones of a beautiful kind are found in the bed of the Chambal." [6] They are collected in large quantities at Kaparwanj (Kapadvanj), in the Kaira district, Gujarát, and in the bed of the river Májam between Amliala and Mandwa, about 15 miles from Kaparwanj, "in rolled balls of spheroidal, reniform, and amygdaloidal figures, from ½ to 10lb in weight." [7] It is also said that they are met with in the Rajahmundry district.[8]

Newbold mentions them as being obtained in the localities already given, on his authority, for moss-agate.

Onyx is another variety of chalcedonic stone found in the Deccan trap. That which has come under the writer's eye in the cut and polished state (as at Jabalpur, where it is sold by the lapidaries) has been mostly black, and opaque white, in alternate bands; sometimes also with bands of very translucent brown. But such stones have doubtless been artificially treated. The only specimens of the natural stone in the museum are from Bánda, and from the Rájmahál trap, and consist of alternate bands of translucent gray, and (comparatively) opaque white, chalcedony.

[1] A. Summers: Select. Rec. Govt. Bombay, No. IV, p. 28.
[2] F. Fedden: Memoirs, G. S. I., Vol. XXI, p. 134.
[3] Newbold: Jour. Roy. As. Soc. Vol. IX, p. 37.
[4] B. Heyne: Tracts on India, p. 265.
[5] *Vide* "Agate-jasper," p. 72.
[6] R. Irvine: Topography of Ajmere, p. 162.
[7] A. Summers: Select. Rec. Govt. Bombay, No. IV, p. 28.
[8] W. Ainslie: Materia Medica of Hindustan, p. 169.

Onyx, from the Deccan trap, has been recorded as found in the beds of the Godávari, Kistna, and Bhima rivers,[1] and near Hyderabad.[2]

It is said that "onyx of a coarse kind is not uncommon in detached pieces," in Rájputána,[3] and, according to Dr. Mason, it is found at Moopoon, near Maulmain.[4]

Sardonyx has been mentioned as found near Hyderabad,[5] and is amongst the stones sold by the lapidaries at Jabalpur, from whom specimens in the museum were obtained. They have no doubt been treated artificially in the same way as carnelian. The stone noticed by Mr. Summers, under the name of *mora*, as obtained near Ratanpur, in Rájpipla, is perhaps sardonyx, but the description is not very clear.[6]

Flint "almost undistinguishable from fragments of English chalk flints, is found at Coorchycolum, a village in the north-east of the Trichinopoly district, a few miles south of the Vellaur," and also to the south-east of Saintoray. The flint occurs in the upper part of the cretaceous rocks and is believed to form a continuous band.[7] Nodules of the same substance are found in the eastern part of the Mysore district, which were formerly used for making gunflints:[8] the material for these was also obtained in Bellary,[9] and there is an abundant supply 2 miles south of Wodoorti, in the Kapadgod range, Dharwár district.[10]

The cherty bands of the transition limestones in the Narbada valley, noticed below, sometimes pass into flint.

In the hills near Sukkur and Rohri, on the Indus, one portion of the nummulitic limestone, some 200 or 300 feet thick, is very hard, and, especially towards the base, contains "large masses of flint, many of which precisely resemble, in every respect, those of the English chalk. Some of the nodules at Sukkur exceed a foot in diameter. These flints contain sponges and less frequently *Foraminifera*." Cores, and flakes split from them, are scattered about abundantly in some places.[11]

Flint, in true chalk, has been recently described, by Mr. Griesbach as occurring in Afghán Turkistán.[12]

"Immediately across the Kurram, on the Afghán side opposite to Thal, is the very rugged hill of Bakkarkanch (flint-stone). * * *

[1] Newbold: Jour. Roy. As. Soc., Vol. IX, p. 37.
[2] B. Heyne: Tracts on India, p. 265.
[3] R. Irvine: Topography of Ajmere, p. 161.
[4] Natural Productions of Burma, p. 21.
[5] B. Heyne: Tracts on India, p. 265.
[6] Select. Rec. Govt. Bombay, No. IV, p. 31.
[7] H. F. Blanford: Memoirs, G. S. I., Vol. IV, p. 213.
[8] Gazetteer of Mysore and Coorg, Vol. II, p. 194.
[9] Bellary Manual, p. 95.
[10] T. Newbold: Madras Jour. Lit. & Sci., Vol. XI, p. 46.
[11] W. F. Blanford: Memoirs, G. S. I., Vol. XVII, pp. 103, 106.
[12] *Vide* "chalk."

It is chiefly formed of masses of hardened and altered brecciated beds, some being altered limestone or a siliceous rock full of angular fragments of hornstone or flint." [1] Flints, having a chalky white coating, from eocene limestone, obtained in the Namal hills, Bannu, were exhibited in the Lahore exhibition of 1864.[2]

Dr. Romanis has lately observed nodules in limestone at Duyinzeik, north of Maulmain, which "resembled chalk flints. Some were hollow, the cavity inside being filled up with limestone." [3]

Hornstone, generally in the form of a peculiar hornstone breccia, occurs in very massive irregular beds, very often in association with limestone, in some of the transition rocks of India. Thus, hornstone has been described as forming a prominent member of those rocks in the State of Bijáwar, and neighbouring region in Bundelkhand; in the Dhar forest on the Narbada, to the south-east of Indore; in the Son valley; at Bág, some 70 miles west-south-west of Indore; in the country near Gwalior; and near Kaládghi, in Bombay.[4]

Hornstone also occurs as a veinstone (so-called fault rock), especially in the schistose rocks; as in the neighbourhood of the Rámgarh coalfield, in the Hazáribágh district.[5]

Chert is very common, especially in connection with limestones of various ages. Thus, Mr. King has described ferruginous chert bands in the Chey-air beds of the Kadapah (transition) formation, in the Madras presidency.[6] In the transition rocks of Bág, the Dhár forest, and further up the Narbada valley, highly cherty limestone is very abundant, the calcareous and siliceous portions of the rock being interbanded, generally in thin layers.[7] Thin bands and flattened nodules of black chert are common in the Bhánrer (upper Vindhyan) limestone in Rewah and Bundelkhand.[8] The limestone of the Lameta group, in the Central Provinces, "abounds, as a rule, in masses, sometimes irregular, sometimes more or less lenticular in form, of segregated chert," and the same is true of the Bág limestone. Mr. Blanford has suggested that "the occurrence of the chert nodules may be due in both cases to infiltration from the overlying traps, or to deposition from hot springs at the commencement of the volcanic epoch.[9] "Perhaps the most common form of the intertrappean bands" (of the Deccan trap in the Central Provinces), "or that which

[1] A. B. Wynne: Records, G. S. I., Vol. XII, p. 111.
[2] B. Powell: Punjab Products, p. 45.
[3] Report on Minerals of Tenasserim, 1885, p. 5.
[4] Pt. I, pp. 29, 31, 35, 45, 56, 67.
[5] V. Ball: Memoirs, G. S. I., Vol. VI, p. 128.
[6] Memoirs, G. S. I., Vol. VIII, p. 188.
[7] Pt. I, pp. 31, 32, 45.
[8] Memoirs, G. S. I., Vol. VII, p. 83.
[9] Pt. I, p. 309.

is most conspicuous, is a compact blackish cherty rock, a kind of Lydian stone. It is clear that this rock has been originally a silt, and has been hardened, either by the outpouring of igneous rock over it, or by chemical infiltration, the former being the more probable." [1] Perhaps the term 'porcelain jasper' would be applicable to some of this rock.

Plasma.—"The variety of chalcedony called plasma is seen in the Nizam's territories, south of the Bhima, between Sunnoo and Jyattaky; it occurs in an amygdaloid, imbedding green earth, white chalcedony, and calcspar. The white chalcedony is seen distinctly passing into plasma, and the plasma, by different gradations of shades, from translucent apple-green to the dark and almost opaque green, into bloodstone; the colouring matter is the green earth; and the red spots we see in the bloodstone are evidently derived from the bright red bole which here occurs in layers and nests in the amygdaloid. The green colour in some of the white chalcedonies is often disposed in delicate moss-like filaments. On exposure to the blow-pipe, the green of both the plasma and heliotrope is destroyed; that of the plasma changing to a purplish white." This last observation has been confirmed by the writer, with reference to the heliotrope, and the green jasper into which it passes.

The author quoted also says that plasma is found in the beds of the Godávari, Kistna, and Bhima rivers,[2] and Dr. Voysey notices "plasma, or translucent heliotrope," amongst the minerals found in the Deccan trap of the Gáwilgarh hills.[3]

Jasper.—Beds of this mineral occur to some extent in the gneissose rocks of India, but are far less common there than in the transition series. Thus banded jaspers seem to occur somewhat abundantly in the metamorphic rocks bordering the Kadapah district.[4] Quartz passing into jasper, and interbanded with hematite, has been noticed in the gneissose rocks of Bundelkhand.[5]

Jasper is very abundant in the transition rocks, forming a prominent member of the series in many parts of the country. The colour generally varies from dull to bright red, and very frequently the jasper is interbanded with hematite, thus forming a variety of ribbon-jasper. At times the jasper passes insensibly into hornstone and ordinary quartz.

As cases in point, Mr. King has described red and brown jasper beds in the transition rocks of Kadapah district.[6] Mr. Foote speaks of "the splendid ribbon-jaspers so largely developed in the north-eastern ridge

[1] *Ibid.*, p. 311.
[2] T. Newbold: Jour. Roy. As. Soc. Vol., IX, pp. 37, 38.
[3] Asiatic Researches, Vol. XVIII, Pt. I, p. 191.
[4] Pt. I, p. 62.
[5] Pt. I, p. 13.
[6] Memoirs, G. S. I., Vol. VIII, p. 188.

of the Sandur hills" in Bellary.[1] Jasper, very commonly of the banded character described above, and often of a brilliant red, is also abundant in the transition rocks of the Narbada and Sone valleys,[2] and of Gwalior.[3] It also occurs, under similar circumstances, in Chutia Nágpur.[4]

Conglomerates, many of the pebbles in which are jasper derived from beds like those described above, so that in some cases the rocks have been designated 'jasper-conglomerates,' are not uncommon. Such rocks occur in the transition strata of the Kadapah district, the jasper being derived from the metamorphics,[5] while the transition beds of the Bellary and Anantapur districts have furnished "the bright-coloured jasper pebbles which are so striking a feature in the basement and other conglomerates of the lower Vindhyan rocks."[6] The jasper in the Kaimur conglomerate of Bundelkhand, doubtless, had a similar origin.

Jasper, very often of a dark-green colour,—similar in fact to that of heliotrope without the spots, but sometimes red or yellow,—is a very common mineral in the Deccan trap, where it occurs chiefly in flat plates, which appear to have been formed in cracks.[7]

Jasper also occurs in the hills to the east of Assam (as is indicated by the rolled pebbles brought down by the rivers); in the Nicobars;[8] and Andamans.[9]

Heliotrope is not uncommon in the Deccan trap, where it occurs, according to Mr. Blanford, in the same way as the jasper just mentioned. Most of it, indeed, appears to differ from the green jasper merely in the presence of red spots or streaks; but in some cases it would seem more to approach chalcedonic quartz. The transition from heliotrope through plasma into chalcedony, described by Newbold, has already been alluded to.[10]

Amongst the localities where the mineral has been found, the bed of the river Muta-Mula, in the Poona district, has been noticed as producing fine specimens.[11] Near the village of Tankára, in the state of Morvi, Káthiawár, heliotrope is obtained "in massive layers from ½ to 40lb in weight." The stone is partly "green, with flamed streaks or red spotted delineations," partly "more variegated with green,red, and yellow tints."[12]

[1] Records, G. S. I., Vol. XIX, p. 111.
[2] Pt. I, p. 33.
[3] C. A. Hacket: Records, G. S. I., Vol. III, p. 36.
[4] Pt. III, p. 505.
[5] *Ibid.*, Pt. I, p. 62; Memoirs, G. S. I., Vol. VIII, p. 153.
[6] R. B. Foote: Records, G. S. I., Vol. XIX, p. 99.
[7] W. T. Blanford: Pt. I, p. 305.
[8] Select. Rec. Govt. India, No. LXXVII, p. 133.
[9] Records, G. S. I., Vol. XVII, p. 86.
[10] Page 76.
[11] W. Sykes: Trans. Geol. Soc., 2nd Series, Vol. IV, p. 425.
[12] A. Summers: Select. Rec., Govt. Bombay, No. IV, p. 28.

Lydian stone.—As already noted, the dark-coloured chert of the inter-trappean beds in the Central Provinces has been described as approaching Lydian stone in character. The same may, perhaps, be said of the black chert in the Bhánrer limestone.

According to Mr. Hardie, "a conglomerate, containing rounded masses of Lydian stone, quartz, &c.," is one of the rocks forming a group of low hills near the village of Sawah, about 14 miles north of Neemuch, and similar masses are enclosed in a calcareous rock found in the valley of Oodeypore, as well, apparently, as in other parts of Meywar.[1] Mr. Durrschmidt states that in the schistose rocks of Singhbhum "far-stretching dykes of white quartz are frequent; sometimes they are coloured by carbonaceous matter, and have become real Lydian slates (jeweller's touchstone)."[2] It may, perhaps, be doubted whether the rock in question is true Lydian stone, especially as Mr. V. Ball, who subsequently surveyed the same district, makes no mention of such.[3] "Siliceous schist passing into Lydian stone" is stated to occur near Ootacamund.[4]

Pseudomorphous quartz.—A peculiar siliceous veinstone, which is very common in India, especially in metamorphic and transition rocks, and to which, on account of its frequently marking lines of dislocation, the term 'fault-rock' was formerly applied, in one of its forms consists of thin plates of quartz, with long, narrow interstices between them, which are evidently due to the removal of thin tabular crystals of specular iron. Each plate of quartz is composed of indistinct interlocking crystals, which have grown towards, and met in, the centre, or sometimes, when they do not meet, there is a drusy cavity in the middle. The surfaces of the plates are shining and smooth, except where etched by three systems of parallel striæ, which cross each other at angles of 60°. These are doubtless pseudomorphous after the striæ, which often present themselves on the basal planes of tabular specular iron, and which are parallel to the edges between the basal and rhombohedral faces. Some of the cavities are partly filled with limonite, due to the alteration of the anhydrous oxide.[5]

In another form of the rock the quartz is fibrous, and may be pseudomorphous.

Mr. Hardie noticed fibrous quartz, of a slightly reddish tint, with "fibres arranged in a manner similar to those of fibrous gypsum," at Gherwási in Jaipur, Rájputána. It is described as occurring in

[1] Edin. New Phil. Jour., Vol. VII (1829), pp. 117, 119.

[2] Report on Copper Mines of Singhbhum, p. 19.

[3] Memoirs, G. S. I., Vol. XVIII, Pt. 2.

[4] H. Congreve: Madras Jour. Lit. Sci., Vol. XXII, p. 232.

[5] H. B. Medlicott: Records, G. S. I., Vol. VIII, p. 84. V. Ball: Memoirs, G. S. I., Vol. VI, p. 128; Vol. XVIII, p. 76.

"oblong portions of small size," imbedded in metamorphic rocks, but the author does not state whether he considered it pseudomorphous or not.[1]

The chalcedony, already described as so abundant in the Deccan trap, very often contains crystals of calcspar. Owing to the removal of the latter, rhombohedral cavities are frequently met with. Similar pseudomorphs are common in the chalcedony of the Rájmahál trap.

In some cases, again, the crystals of calcite are encrusted with a layer of chalcedony. There is a fine group of this sort now in the museum, obtained by Mr. Fedden from Western Cutch.

Silicified wood.—Certain of the tertiary rocks in many parts of India contain enormous quantities of silicified wood. Thus, Mr. Theobald has given the name of 'fossil-wood group' to one subdivision of the system in Pegu, as the most prominent characteristic is the immense amount of silicified wood occurring in those beds, and washed out of them into newer gravels. The author states that the wood is liable to alteration from absorption of water, being converted into an opaque and earthy hydrate, which readily disintegrates and crumbles away. The analyses given below, however, do not show a large excess of water in the altered mineral. The wood appears to be all exogenous, and of one species.[2] Silicified wood is also extremely abundant in the Tipam group of Upper Assam.[3] In some parts of Western Sind, "and especially in the neighbourhood of the Laki range, silicified fossil-wood is found in abundance in the Manchhar beds, stems of large trees being of common occurrence. The majority are dicotyledonous, but some fragments of monocotyledons are also found."[4] In the conglomerate of Perim island, in the gulf of Cambay, "immense masses of fossil-wood occur, very hard, heavy, and black."[5] The wood there would seem to resemble some of that in Assam, in containing more or less carbonaceous matter mixed with the silica. The Cuddalore beds contain "exogenous silicified fossil-wood, some of which is coniferous, and has been described under the name of *Peuce schmidiana*. * * * This silicified wood is especially abundant at Tiruvakári (Trivicary), about 14 miles west-north-west of Pondicherry. * * * The trunks of trees occurring at this place are of large size, one having been found as much as 100 feet in length, whilst stems 15 to 20 feet long, and 5 or 6 feet in girth, are not uncommon. They occur prostrate, imbedded in ferruginous grit."[6]

Silicified wood also occurs in some of the intertrappean beds of the

[1] Asiatic Researches, Vol. XVIII, Pt. 2, p. 85.
[2] Records, G. S. I., Vol. II, p. 79; Memoirs, G. S. I., Vol. X, p. 247.
[3] F. R. Mallet: Memoirs, G. S. I., Vol. XII, pp. 297, 301.
[4] W. T. Blanford: Memoirs, G. S. I., Vol. XVII, p. 64.
[5] *Ibid.*, Vol. VI, p. 375.
[6] Pt. I, p. 336; J. Warren, Asiatic Researches, Vol. XI, p. 1.

Deccan trap. Dr. Spry found palm-trunks of this kind at Saugor.[1] Near the village of Cotandem, 48 miles from Goa, silicified wood occurs over an area of several square miles, in rock which is covered in places by trap.[2] In some of the Rájmahál intertrappean strata "there occur in the greatest abundance, silicified trunks of trees, chiefly exogenous, and more a or less perfect. The majority of these vary from one foot to eighteen inches in diameter, while some are seen so much as three or four feet across. Sometimes the rock seems to be made up of a mass of small stems or twigs."[3]

Such specimens of the above fossil-woods as have been examined were all essentially quartz-silica, not opal; and the same may, possibly, be true of all them. Analyses by Mr. Tween of the Pegu wood afforded :—

	Unaltered.	Altered.
Silica	98·9	94·27
Oxide of iron, alumina, and lime	...	3·93
Water	1·1	1·80
	100·0	100·00

The wood is so hard that it is used by the Burmese for striking fire with steel. Specimens respectively from the upper tertiary rocks, in the North Cachar hills; from the Rájmahál intertrappean beds (coniferous); and from the Deccan trap (palm), have been lately examined by Mr. Blyth. On ignition they only lost ·90,·95, and ·50 per cent. in weight, and a hot solution of caustic potash did not extract more than a few per cent. of silica.

Opal.—Precious opal is not known with certainty to occur in India. Within the last year the writer has seen very fair specimens, which were said to have been discovered not long before in India, and, as the writer has some reason to believe, within the area of the Deccan trap; but the owner was not very communicative on the subject.

Opal, varying from a bluish-white translucent variety to an opaque white one, is common in parts of the Deccan trap area, occurring in nodules of various sizes in the amygdaloids. Thus, Dr. Heyne states that "semi-opal is found near Hyderabad inland. The colour of the best is bluish-white. Others partake of a reddish, and somewhat fiery effulgence, when placed between the eye and the sun. They have a glassy lustre, and are strongly translucent. Fracture conchoidal; hardness equal to that of quartz. Specific gravity between 2·09 and 2·063. They strike fire with steel, which I believe is peculiar to this variety of opal.

[1] Jour. As. Soc. Bengal, Vol. II, p. 639.

[2] C. Marchesetti: Jour. As. Soc. Bombay, Vol. XII, p. 215.

[3] T. Oldham: Palæontologia Indica, Ser. II, Vol. I, p. 5; Memoirs, G. S. I., Vol. XIII, p. 217.

When exposed to the air it becomes opaque."[1] Colonel Sykes, again, notes that at "Oondurgaon, and up both banks of the Seena river to Purrunda" (in the Poona district), "numerous and very fine specimens of milk-opal, with a flame-coloured tinge in transmitted light, are found on the surface." The same author mentions "semi-opal or cacholong" amongst the trap minerals.[2] Dr. Voysey notices "common and semi-opal" as occurring in the same rocks in the Gawilgarh hills.[3] The plain of Bejapore and Sitabaldi are other localities given by Captain Newbold for common opal, who further says, "The cacholongs which occur in the plain of Bejapore are usually milk-white, and present both the hard and soft earthy varieties noticed by Brongniart in the cacholongs of Champigny; the former exhibits a shining fracture, while the latter is chalky, light, and adheres to the tongue."[4] The authors quoted do not seem to agree altogether in their nomenclature. It may, perhaps, be said that the mineral is common opal, verging on the one hand towards, or into, gyrasol, and on the other into cacholong.

Opal, similar to that of the Deccan trap, also occurs in the trap of the Rájmahál hills. Masses up to one or two feet in diameter have been observed by the writer near Sáhibganj railway station.

The trap opal sometimes contains pseudomorphous cavities, after crystals of calcite, similar to those already noticed under pseudomorphous quartz.

Beyond the trappean limits opal has not often been observed. It has been noticed, but only in small quantity, at Puga, in Rupshu, with native sulphur, gypsum, and kalinite.[5] At Rutland island, in the Andamans, small seams of brown opal occur in serpentine.[6]

Tabasheer is a siliceous substance which is sometimes found inside the bamboo, at and near the joints both above and below the septum. It it said that in India it occurs in the bamboo of certain parts of the country, only, amongst which Sylhet, Nágpur, Hyderabad, the neighbourhood of Vizagapatam and Vellore, and part of the Malabar coast, are mentioned. It is only found in some stems, and in those which contain it, it only exists in certain joints. Out of twenty-eight stems holding the substance, some contained it in one or two joints and none in more than three. The substance exists originally in solution in the water which is sometimes found in the joints, and from such solution the tabasheer is deposited.

[1] Tracts on India, p. 264. The hardness given is higher than that of any specimens examined by the present writer.

[2] Trans. Geol. Soc., 2nd Series, Vol. IV, p. 424.

[3] Asiatic Researches, Vol. XVIII, Pt. I, p. 191.

[4] Jour. Roy. As. Soc., Vol. IX, p. 39; Madras Jour. Lit. & Sci., Vol. XII, p. 27.

[5] Memoirs, G. S. I., Vol. V, pp. 163, 168.

[6] Records, G. S. I., Vol. XVII, p. 80.

It varies in appearance; some specimens have a "milky transparency, transmitting a yellowish, and reflecting a bluish-white light;" some are "of a bluish-white colour and pearly lustre, not unlike chalcedony in appearance, but much softer;" others, again, are white and opaque. When put into water the substance emits a large number of air-bubbles and absorbs a quantity, frequently more than its own weight, of the liquid, the first-mentioned kind becoming almost perfectly transparent when so saturated. It phosphoresces when heated. The index of refraction of the transparent kind was found to vary between 1·1115 and 1·1535. A specimen of the bluish-white kind (H=2·5) yielded on analysis—

Silica	90·50
Alumina	·40
Ferric oxide	·90
Potash	1·10
Loss on ignition	4·87
	97·77

The loss on ignition was chiefly water, but not entirely, a peculiar odour exhaled indicating the presence of a small quantity of vegetable matter. Tabasheer is readily soluble in caustic alkali, and slightly so in water.[1]

It should be noted that in a much later analysis of tabasheer, from Java, the amount of potash is much greater (nearly 5 per cent.) than that given above—a point of importance with reference to the solubility of the substance in water.[2]

The specific gravity of a sample of nearly opaque white tabasheer, obtained in the Calcutta bazár, was determined by the writer: 53·63 grains (dried over oil of vitriol) weighed 109·99 grains when fully saturated with water, and, in that condition, displaced 80·72 grains of water.[3] This gives a specific gravity of ·664 for the tabasheer, inclusive of the pores, and 2·202 for that of the substance, exclusive of the pores. The absorption of water was 105·1 per cent. by weight of the dry tabasheer: 69·8 per cent. of the total bulk of the dry substance was occupied by the pores, and 30·2 by the actual tabasheer itself. The sample, when saturated with water, was bluish and highly translucent.

[1] P. Russell, Phil. Trans., 1790, p. 273; J. Macie, *Ibid.*, 1791, p. 368; D. Brewster, *Ibid.*, 1819, p. 283; T. Thomson, Madras Jour. Lit. and Sci., Vol. IV, p. 490. An analysis by E. Turner is given in the Edin. Jour. Sci., Vol. VIII (1828), p. 335, but the writer has not access to that journal.

[2] Watt's Dictionary of Chemistry, quoting Rost van Tonningen, Jahresb, 1860, p. 531.

[3] During the process of taking the specific gravity, 0·11 grains of the substance was dissolved, for which allowance was made.

II.—Ternary Oxygen Compounds.

1. Silicates.

A.—Anhydrous Silicates.

(*a*) Bisilicates—General formula $RSiO_3 = RO.SiO_2$.

Enstatite appears to have been only noticed microscopically in certain peridotites from Ladákh.[1]

Bronzite is said to be of very common occurrence in gabbro, in the Arakan range, and in some of the Nicobar islands.[2] 'Metalloidal diallage' has been observed in the valley west of Snowdon, in the Nilgiri hills, but the author was uncertain whether it should be referred to bronzite or hypersthene.[3]

Hypersthene.—According to Captain Newbold, "hypersthene is occasionally seen in the hornblende schist of the ceded districts."[4] It is also said to occur, in basaltic greenstone, in Mysore;[5] and in greenstone, east of Tavoy.[6] The identity of the mineral is, perhaps, not altogether beyond doubt in one or two cases.

Wollastonite.—Close to the village of Ráondi, in South Rewah (lat. 23° 56′, long. 82° 32′), in two patches of gneiss occurring as inliers in the Tálchirs, limestone is very abundantly met with, the same beds being probably repeated by folding. It is a white crystalline rock, varying from a saccharine variety to one with cleavage facets of ¼ inch across. The band to east of Ráondi contains a very large amount of wollastonite. In fact, the rock is entirely composed of this mineral in places, constituting there a 'wollastonite schist,' which, from its greater resistance to atmospheric influences, often stands up above the general surface in a low jagged ridge. The mineral has a greyish-white colour and bright pearly lustre, and the approximate parallelism of the principal cleavage faces gives the rock a somewhat fissile structure.[7]

The same mineral has been noticed by Mr. Foote, with coccolite, in crystalline limestone, on the west side of the Vijayapatti creek in South Tinevelly.

Pyroxene.—As a constituent of the Deccan and other traps of India, pyroxene is very widely diffused, but it has rarely been found in

[1] C. A. McMahon: Records, G. S. I., Vol. XIX, pp. 116, 118.
[2] Pt. II, pp. 714, 735.
[3] H. Congreve: Madras Jour. Lit. & Sci., Vol. XXII, p. 237.
[4] Trans. Roy. As. Soc., Vol. VIII, p. 153.
[5] Mysore and Coorg Gazetteer, Vol. I, p. 24.
[6] Natural Productions of Burmah, p. 25.
[7] F. R. Mallet: Records, G. S. I., Vol. VI, p. 42.

distinct crystals. In the Deccan trap "no crystallized pyroxene has been observed except locally in some of the ash-beds."[1]

Diallage has been reported from several localities, but it is doubtful whether the mineral so described should in every case be referred to pyroxene. It is common in gabbro and serpentine in some of the Nicobar islands,[2] and the Arakan Yoma, and diallage rocks are spoken of as common in "Ava proper."[3] The mineral is disseminated through serpentine in the Hánlé and Puga valleys, Ladákh.[4] Captain Newbold states that he had only met with diallage rock in two localities in Southern India,—*viz.*, in the Salem district and at Bannawara, about 8 miles west from Bangalore. In the latter case it appeared to form a dyke or vein in gneiss and mica schist.[5]

Sahlite and *smaragdite* are amongst the minerals described as occurring in the Nilgiri hills.[6]

The garnet rock which occurs in subordinate masses in the metamorphic rocks of parts of Chutia Nágpur, and Southern India, not unfrequently passes into one composed of garnet and *coccolite*.[7] The latter also occurs disseminated through crystalline limestone, as near Vizianagram.[8] The mineral, however, has not been analysed.

Rhodonite.—There is a specimen of this mineral in the museum, which was obtained by the writer from a *lohari*, who found a quantity of it a foot or two beneath the surface, in the southern part of the Mirzapur district. From its weight he had supposed it to be iron ore, and attempted to smelt it as such.

The rhodonite associated with the braunite of Rámtek, near Nágpur, has already been noticed.[9]

Amphibole—*Tremolite*.—The most common habitat for this mineral, as far as the writer's experience goes, is the dolomitic limestones of the transition and metamorphic rocks. That magnesia-lime-hornblende should be of frequent occurrence in dolomite is indeed what might be expected. The mineral also occurs in the schistose rocks of the same series.

The following are a few of the localities where tremolite has been noticed:—

[1] W. T. Blanford: Pt. I, p. 305.

[2] *Ibid.*, Pt. II, p. 735.

[3] J. W. Helfer: The Provinces of Ye, Tavoy, and Mergui, p. 26.

[4] Memoirs, G. S. I., Vol. V, pp. 128, 168.

[5] Jour. Roy. As. Soc., Vol. IX, p. 9. An analysis by Captain J. Campbell, of "black diallage" which is said to form the pillars of Sultan Tippoo's tomb at Seringapatam, is given in the Calcutta Jour. Nat. Hist., Vol. VI, p. 199. But it is admittedly imperfect, and is remarkable as including no lime.

[6] H. Congreve: Madras Jour. Lit. & Sci., Vol. XXII, pp. 233, 234, 237.

[7] Records, G. S. I., Vol. VII, p. 34.

[8] W. King: Records, G. S. I., Vol. XIX, p. 155.

[9] Page 56.

Adepuram, Nellore. Asbestiform tremolite found in veins, with adularia and magnetite, in mica slate.[1]

West of Rumpaid, Kandiconda taluq, Hyderabad. White fibrous tremolite, found by Dr. King in the limestone of the Kadapah series.

Korhádi, near Nágpur. "Coarsely crystalline saccharoid dolomite, with long white crystals of tremolite, very like some specimens from the Val Tremola, St. Gotthardt."[2]

Retournah, north-west of Sunpur Khás, Jabalpur district. White tremolite found by Mr. Hacket in crystalline limestone. At and near the marble rocks, in the same district, straw-coloured tremolite occurs in dolomite.[3]

Bichi river, South Mirzapur. Large and brilliant crystals of greyish tremolite, in dolomite.[4] In some places (*e.g.*, west of Dumrahur and Urjhut) in the same district, bands of light-grey crystalline-massive tremolite rock occur in the gneiss. They are an unusual variety of the hornblende rock which is so abundant in the metamorphics.[5]

Ulwur in Rájputána. Tremolite and actinolite common in crystalline limestone.[6]

áraganda copper mine, in t he Hazáribágh district. Irregular layers of tremolite and actinolite schist occur in micaceous and chloritic schists.

Mánbhum. Tremolite and actinolite are amongst the minerals occurring in the metamorphic rocks.[7]

Jade is largely worked in the Karakásh valley on the southern borders of Turkistán (Pt. III, p. 517).

Since the issue of Mr. Ball's work the Karakásh jade has been examined by Mr. C. L. Allen, in the laboratory of the Virginia University. The specimen (one of those brought by Dr. Stoliczka) is described as forming "a compact, extremely tough mass, of very pale sea-green colour, and lustre between vitreous and pearly; streak white. Translucent. Hardness = 6·5. Specific gravity = 2·98. Analysis gave :—

Silica	57·35
Alumina	1·03
Ferrous oxide	1·22
Magnesia	22·73
Lime	13·40
Soda	·25
Potash	·23
Water	2·69
	98·90

[1] T. Newbold : Madras Jour. Lit. and Sci., Vol. XII, p. 28.
[2] S. Haughton : Jour. Roy. Dublin Soc., Vol. II, p. 176.
[3] J. Franklin : Asiatic Researches, Vol. XVIII, Pt. I, p. 34.
[4] F. R. Mallet : Records, G. S. I., Vol. V, p. 20.
[5] *Ibid.*, p. 22.
C. A. Hacket : *Ibid.*, Vol. X, p. 85.
[7] V. Ball : Memoirs, G. S. I., Vol. XVIII, p. 43.

which corresponds essentially to the formula $(\frac{7}{10}\,Mg + \frac{3}{10}\,Ca)\,SiO_3$. The hydrogen of nearly all the water is regarded as basic.[1]

The so-called "zeolitic mineral," occurring with the Karakásh jade, is, there can be little doubt, dolomite (as suggested by Mr. Ball), firstly because dolomite is a common habitat of tremolite; and secondly, because in one or two specimens brought by Dr. Stoliczka, and now in the museum, the jade is mixed with coarsely crystalline white dolomite.[2]

The tremolite rock, already noticed as occurring in South Mirzapur, in some places (more noticeably between Kotamaua and Bamni, and the top of Kurea ghát) passes into a finely granular, to nearly compact, variety, forming a coarse jade.[3] The specific gravity of the mineral is 3·10. Like the jade of the Karakásh valley, it fuses before the blowpipe with some difficulty, and with intumescence.

A stone, known in commerce as jade, is extensively worked in the Mogoung district of Upper Burma. With reference to it, *vide* jadeite.[4]

Actinolite is not unfrequently met with in the metamorphic and transition rocks, in the form both of actinolite schist and of crystals disseminated through talcose and other schists, limestone, &c.

Asbestos has been found in parts of the Madras presidency, in Chutia Nágpur, in Afghánistán, in the Punjab, and in Garhwál (Pt. III, p. 519).

Hornblende occurs in immense quantity in the metamorphic rocks, sometimes by itself in the form of hornblende rock, but usually as a constituent of such, and of hornblende schist, syenitic gneiss, &c. Hornblende also forms a constituent of some of the transition rocks, and is likewise found in some of the volcanic, *e.g.*, in the andesites of Narcondam, and the ash-beds of the Deccan trap.[5]

Beryl.—The chief localities where this mineral has been obtained are in the Coimbatore district, and in the Punjab Himalayas. It has also been found in Hazáribágh and some other places (Pt. III, p. 520).

Mr. Tellery, manager of the Jaipur state garnet works, has lately examined some beryl localities in Rájputána. He writes that the Toda Rai Singh beryl mines were once worked on a considerable scale, but have been stopped for the last twenty years. The mineral also occurs in the country surrounding Toda Rai Singh, up to Panwar, Malpura, and

[1] Chemical News, Nov. 1882, p. 216.

[2] Some time ago a small specimen of jade (S.G.=3·02), which was said to have come from Central Asia (Karakásh ?), was presented to the museum by Sir O. St. John, then Resident in Káshmir. It is cut *en cabochon*, and shows a band of light similar to that of an inferior quartz cat's-eye. Doubtless the jade is fibrous in structure, like some of that from Karakásh, as stated by Dr Stoliczka.

[3] Records, G. S. I., Vol. V, p. 22

[4] Page 94.

[5] Memoirs, G. S. I., Vol. XXI, p. 282; Manual, Pt. I, p. 312.

Diggi, as well as at Newai, in Tonk. Mr. Tellery carried out experimental diggings at Toda Rai Singh, but the beryl found, although of good colour and lustre, was in such small pieces as to be unsaleable.[1] The position of the Toda hills has been given under chrysoberyl.[2] Panwar is 8 miles south, and Malpura and Diggi respectively 27 and 33 miles north of Rájmahál. Amongst a number of specimens, picked up in the neighbourhood of Shahpura (a town 38 miles west-south-west from Rájmahál), recently sent to the museum, by the Political Agent of Haraoti and Tonk, for determination, were several pieces of pale blue and green beryl. Some were clear enough for cutting, but only of small size.

It would seem, therefore, that beryl is by no means an uncommon mineral over a considerable area in part of Rájputána : perhaps it may be inferred that its matrix is the granite which penetrates the transition rocks in numberless dykes.

Beryl has also been found, in vein-granite, at Ungool and Ramidi, on the borders of the Tálchir coal-field, in Orissa.[3] Of two crystals from the former locality in the museum, which are about an inch in diameter, one is white and nearly opaque and shows the faces ∞P. ∞P2. 0P. The other is yellowish without termination. A yellow crystal from Ramidi exhibits the combination ∞P. ∞P2. 2P2. P.

(*b*) Unisilicates—General formula $R_2 SiO_4 = 2RO. SiO_2$.

Chrysolite.—Olivine is common as a constituent of the doleritic lavas of the Deccan trap, occurring in translucent yellowish grains[4] and sometimes in well-formed crystals.[5] Some portions of the Rájmahál trap also contain "large quantities of olivine."[6] The mineral is a constituent of the Barren island lavas, and the sand on the beach, at the anchorage there, is composed almost entirely of olivine and bottle-green translucent augite.[7] Olivine is the chief constituent of certain eruptive rocks (peridotites) occurring in Ladákh.[8] Dr. Hooker states that at some spots in the neighbourhood of Kinchinjhow, in the Sikkim snowy range, "much olivine is found in the fissures of the gneiss."[9] It seems possible that the mineral may be epidote, and the same may, perhaps, be said

[1] Report on Jaipur garnet works for 1885, p. 4.
[2] Page 53.
[3] Memoirs, G. S. I., Vol. I, p. 36.
[4] Pt. I, p. 304.
[5] P. N. Bose : Memoirs, G. S. I., Vol. XXI, p. 52.
[6] T. Oldham : Palæontologia Indica, Ser. II, Vol. I, p. 2. Memoirs, G. S. I., Vol. XXI, p. 274.
[8] C. A. McMahon : Records, G. S. I., Vol. XIX, p. 115.
[9] malayan Journals, Vol. II, p. 123.

of the "chrysolite" mentioned by Dr. Irvine as occurring near Ajmere.[1]

Garnet.—In innumerable parts of India garnet is common, and often extremely abundant, in the metamorphic rocks. It is also of frequent occurrence in the transition and plutonic. According to Captain Newbold, in Southern India garnet is found in the metamorphic schists in greater abundance where they are in contact with plutonic rocks, or trap dykes, than elsewhere.

Mr. Ball has described, from an economic point of view, some of the more important localities where garnet is known to occur (Pt. III, p. 521). There is little that can be added of a more purely mineralogical character; but one or two analyses have been made, so that means for classifying Indian garnets into groups are almost entirely wanting.

Lime-alumina garnet.—A few miles north of Ootacamund, in the Nilgiri Hills, Dr. Benza found a rock composed of garnet, which he believed to be cinnamon-stone, hornblende, felspar, and mica.[2] Garnets, of which "many assimilate essonite," are described by Captain Newbold as occurring in the gneiss of Nellore.[3]

Magnesia-alumina garnet.—According to the same author, "pyrope is said to be found in the central parts of the peninsula"[4] (in Southern India); and Dr. Mason states that "a variety of garnet, either identical with, or nearly resembling, the pyrope garnet, is brought from Burma. It is characterized by giving to transmitted light a yellow tinge."[5]

Iron-alumina garnet—"Precious garnet" has been reported from many places, and the mineral is worked in several parts of India (Pt. III, p. 521). But in the absence of analyses it would, perhaps, be unsafe to assume that all such should be referred to this group.

Since the publication of Mr. Ball's work, Mr. Tellery, manager of the Jaipur state garnet works, has issued his first annual report (1885). He writes that the garnets of the Sarwar mines (which some 25 years ago are said to have brought in a revenue to the state of ₹50,000 per annum), although not as large as those found in the Kakoria quarries, are unequalled for colour and lustre by any in the world; and were it not for their possessing a too violet tint, which is not in favour in Europe and America at present, they would in every way excel the Kakoria stones.[6]

[1] Topography of Ajmere, p. 161.

[2] Madras Jour. Lit. & Sci., Vol. IV, p. 266.

[3] Jour. Roy. As. Soc., Vol. VII, p. 153.

[4] Jour. Roy. As. Soc., Vol., VIII, p. 152.

[5] Natural Productions of Burma, p. 23.

[6] Kakoria, in the state of Jaipur, is probably the same as Kakor of the Indian Atlas; lat. 26° 1′ long. 75° 59′.

Mr. Tellery states that there are garnet quarries, in Meywar, near the villages of Bansra, Bendira, Pur Dhadhia, and Sangwa, which have been worked considerably of late years, but the stones, as a rule, are not of very good quality, and the quarries are not as rich as those at Sarwar and Kakoria. There are several others situated in the lands of thakurs, who do not work them as they fear it might lead to confiscation. One of these is near Kekri, in Ajmere, which, however, only contains small stones. Small but very good garnets were also noticed between Babai and Khetri.[1]

Judging from the colour, quality, and size of the stones found in some of the Rájputána quarries, Mr. Tellery hazards the opinion that the oriental garnets mentioned by the ancient writers must have come from that part of India.

Lime-iron garnet.—In the metamorphic rocks of the Hazáribágh district irregular beds of massive garnet, sometimes of considerable thickness, are met with.[2] This rock, to which the name "Calderite" was applied by Mr. H. Piddington, has been analysed by Mr. Tween with the following result :—

Silica	37·44
Alumina	6·27
Ferric oxide	19·38
Ferrous oxide	5·24
Manganous oxide	traces
Lime	30·93
Magnesia	1·40
	100·66

Figures which give the proportion

$$3RO : \dot{R}O_3 : SiO_2 = .220 : .182 : .619.$$

giving the usual formula

$$(R_3 \dot{R})_2 Si_3 O_{12} \text{ or } (R_3 \dot{R}. O_3)_2 \cdot 3SiO_2$$

The specimen analysed had a specific gravity of 3·735.

The specimens of this massive garnet which have passed through the writer's hands, in the field and in the museum, have been mostly dark yellowish-brown, with a resinous lustre, and translucent on the edges : sometimes the mineral is nearly black ; in other cases considerably lighter. Taking its colour, lustre, and composition into account, the mineral, or a great deal of it at least, ought to be called colophonite.

[1] The chief town of a tributary state in Jaipur.

[2] H. Piddington : Jour. As. Soc. Bengal, Vol. XIX, p. 145 ; Vol. XX, p. 207 ; F. R. Mallet, Records, G. S. I., Vol. VII, p. 34.

More or less quartz is often disseminated through the garnet (to which, very likely, the slight excess of silica in the above analysis should be attributed), and the mineral is, in some places, intimately mixed with coccolite, this compound rock and the massive garnet passing into each other.

"A mineral from Nepal named Calderite is, according to Söchting, massive garnet."[1]

Captain Newbold mentions "conformable beds of a granular garnet rock in the hornblende and mica schist" near Gurumanipenta, in Nellore,[2] and there are specimens in the museum of garnet rock, from the Coimbatore district, which vary in colour from yellowish-brown to light yellow and yellowish-white. In the latter variety possibly the amount of alumina is larger and the garnet may approach grossularite.

The author just quoted states that colophonite is not uncommon in Salem, Nellore, Mysore, the Nilgiris, the Carnatic, and other parts of Southern India. He further mentions green garnet, which should perhaps be referred to this group, as occurring in quartz-veins penetrating hornblende schist, at Sankerydroog, in Salem.[3]

Manganese-iron garnet?—A specimen of massive garnet (so-called "Calderite)," from Katkamsandi, 12 miles north-west of Hazáribágh, of a dark brown or black colour and resinous lustre, with a specific gravity of 3·65, was analysed by Mr. Piddington, who gives the result as follows[4]:—

Silica	46·35
Alumina	·35
Lime	1·00
Arsenic	·20
Perox. iron	30·18
Protox. manganese	21·00
Loss, partly traces of fluorine	·92
	100·00

This gives the proportion:—$3RO : R_2O_3 : SiO_2$: .105 : .192 : .766, or about 2 : 4 : 15. The excess of silica may be attributed to the free quartz which the author says was disseminated through the specimen, but the divergence from the normal ratio between the sesquioxides and protoxides is extremely wide. Taking this into account, and the inaccuracy of one or two other analyses by the same author, the above analysis

[1] Amer. Jour. of Science, 2nd Series., Vol. XXVIII, p. 135, quoting Kengott's Min. Forsch. for 1856-57, p. 115. The writer has not access to the original work.

[2] Jour. Roy. As. Soc., Vol. VII, p. 153.

Ibid., p. 224.

[4] Jour. As. Soc. Bengal, Vol. XIX, p. 145; Vol. XX, p. 207.

must be regarded as highly dubious.[1] The Hazáribágh garnet very possibly varies considerably in composition, but it scarcely seems probable that it does so to such an extent as the two analyses quoted would indicate.

Chrome garnet.—Near the Hánlé monastery, in Rupshu, Káshmir, loose blocks of chromite were found by the writer, which were traversed by extremely thin seams of an emerald-green mineral, occurring in brilliant, minute, rhombic dodecahedrons. Unfortunately the mineral was only observed when leaving the spot, or much better specimens might perhaps have been obtained: as it was, the amount that could be devoted to an analysis was not sufficient for a trustworthy result. But there can be no reasonable doubt that the mineral is chrome garnet, taking into consideration its crystallization, its containing a large amount of chromium, and its perfect similarity in appearance to ouvarovite from the Urals, which it also resembles in its mode of occurrence with chromite.[2]

It should be remarked that most of the garnets alluded to above have been, apparently, named from their outward appearance only. Some of the determinations, therefore, must be regarded as doubtful in as far as variety is concerned.

The only garnets in the museum collections noticeable on account of their crystallization, are from the old Máhabágh lead mine on the bank of the Patru river, in the Hazáribágh district,[3] and from north-west of Saidapuram, Gudur taluq, Nellore.

The former are crystals up to three-quarters of an inch in diameter, resembling cinnamon-stone in colour, embedded in calcite with coccolite, and with lustrous faces of the forms ∞O. $30\frac{3}{2}$. 202. The latter are rhrombic dodecahedrons up to two inches across. Regarding the Nellore locality Dr. King writes: "The garnets in these beds (gneiss) are sometimes quite remarkable in their size, beauty of crystallization, and number."[4]

Zircon.—Nicols, writing about the middle of the seventeenth century concerning zircon, stated that "they are found in Ethiopia, India, and Arabia. The Arabs distinguish three kinds:—1, Rubri coloris; 2,

[1] The theoretical composition of pure manganese-iron garnet is given by Mr. Bauerman as follows (Text-Book of Mineralogy, Vol. II, p. 183):—

SiO_2	32·55
Fe_2O_3	28·93
MnO	38·52
	100·00

[2] Memoirs, G. S. I., Vol. V, p. 167.
[3] Records, G. S. I., Vol. VII, p. 34.
[4] Memoirs, G. S. I., Vol. XVI, p. 134.

Citrini coloris; 3, Antimonii coloris. Of these the worst is found in the river Isera, which is upon the confines of Silesia and Bohemia. The best and most excellent ones are brought from Cananor, Calicut, and Cambia."[1] "Cambia" is doubtless Cambay (spelled Cambaya by Tavernier, 1684) which then, as now, was famed for its lapidaries, the stones they cut, however, being obtained from various parts of India, and abroad.[2]

"Zircon is said to occur in the alluvium at Ellora,"[3] and Count de Bournon describes a parcel of corundum received from the same district, as being mixed with crystals of zircon. "These crystals, which were in perfect condition, deserve to be mentioned, not only on account of their size, but also on account of the great number of varieties and rare forms they exhibit. Such, for instance, is the primitive very obtuse octahedron, which is in large crystals, with sides of more than six lines in length. * * * The most usual colour of these crystals of zircon is a brown, which sometimes inclines to yellow: they often, however, have that fine yellowish-red colour which causes this stone to be distinguished by the name of hyacinth." The angles given by the author show that the primitive octahedron spoken of is the same as that taken as P. in more recent works.

The same author also observed minute yellowish-red or orange crystals, which he believed to be zircon, in the matrix of corundum[4] (from the Salem district?, *vide* p. 46).

"In the bed of a nullah, which crosses the Ungool and Cuttack road near Rasul" (36 miles west-north-west of Cuttack) "a granite-vein occurs, containing good crystals of zircon much resembling the Arendal variety."[5] Besides a specimen from the above locality, there is also one in the museum from Hindol, 8 miles west of Rasul. The latter is also in granite, and shows the faces $\infty P\infty$. ∞P.P. $P\infty$. mPm.

Crystals of hyacinth, "which are quadrangular prisms, terminated by quadrilateral pyramids," have been observed in the granite of Kedarnath, at the head-waters of the Ganges. They are not very common, and do not exceed the twentieth of an inch across.[6]

Zircon has been also found in granite-veins near Cherrapoonjee, in the Khási hills.[7]

De Bournon remarks that "the primitive octahedron is found both

[1] As quoted by Mr. Streeter (Precious Stones and Gems, p. 311). The original work is not accessible to the present writer.

[2] Pt. III, p. 507.

[3] T. Newbold: Jour. Roy. As. Soc., Vol. VIII, p. 156.

[4] Phil. Trans., 1802, p. 298.

[5] W. T. Blanford: Memoirs, G. S. I., Vol. I, p. 37.

[6] J. D. Herbert: Jour. As. Soc., Bengal, Vol. XI. p. li.

[7] T. Oldham: Memoirs, G. S. I., Vol. I, p. 111.

in large crystals" (of zircon) "of a yellowish-brown, from the peninsula of India, and in small red crystals from Pegu."[1] The latter probably came originally from Upper Burma. Tavernier mentions "jacinths" as amongst the stones found in the ruby mines of Burma (the kingdom of Pegu as he puts it),[2] and Dr. Romanis has recently found zircon in crude stream gold from the sand of the Meza river, a western affluent which joins the Irawadi about 139 miles above Mandalay.[3]

Idocrase is said to occur in syenite at Dodabetta, in the Nilgiri hills.[4] and is mentioned by Mr. Ball as amongst the minerals found in the metamorphic rocks of Mán bhum.[5]

Amongst a number of specimens, sent for determination by the Political Agent of Haraoti and Tonk about a year ago, were some pieces of *egeran* from a quarry at Jaola, 8 miles north-east of Tonk. Further enquiry led to the discovery of the same mineral, and in much better specimens, at the Rer quarry, on the northern side of the Chattarbhaj hills, near the Banás river (a few miles north-east of Tonk). These are now in the museum. The mineral is considerably lighter in colour than that from Norway, and has a sub-columnar structure of an irregular kind (not in one, but in various directions). Associated with it are quartz and calcite, the rock in which the mineral occurs being transition.

Epidote is of common occurrence in the crystalline, especially in the gneissose, hornblendic and granitoid rocks of India. It is found sometimes as a constituent of the rock, either in association with, or replacing, hornblende; in other cases in veins through it; and more rarely occurs in the form of beds of epidosite. The mineral is also met with in some granitic and trappean rocks. In the Bellary district, for instance (to quote one example out of many), "the most remarkable accessory mineral in this" (finer-grained) "part of the gneiss is pistacite, which occurs very largely in veinlets and in films lining the sides of planes of jointing. It is common, too, in grains in the mass of the rock. Where the rock is much weathered, as it often is, the country is thickly strewn with fragments showing brilliantly yellow-green pistacite, contrasting in a very pleasing way with the red or bright-pink felspar. This pistacite is specially characteristic of the granite gneiss at and around Maddikeri, a few miles north-east of the Guntakul railway junction. Much pistacite in films occurs also on the joint planes in blocks of diorite in the great trap

[1] Catalogue de la Collection Minéralogique du Comte de Bournon, faites par lui-même, 1813, p. 25.

[2] Page 40.

[3] Page 2; Chemical News, Dec. 3rd, 1886, p. 278.

[4] H. Congreve: Madras Jour. Lit. & Sci., Vol. XXII, p. 248.

[5] Memoirs, G. S. I., Vol. XVIII, p. 103.

dykes of this region."[1] . . . "In the rocky hills lying west of Gooty the granite gneiss, and further south the banded hornblendic gneiss, is greatly cut up by red pistacite granite in very irregular veins of all sizes. The granite is a ternary rock consisting of white quartz, red or pink orthoclase, and bright-green pistacite."[2] As illustrative of the occurrence of epidote in subordinate beds, as well as in veins, and also, perhaps, as a constituent, the gneiss of South Mirzapur may be quoted.[3]

Epidote is mentioned by De Bournon as one of the minerals occurring in the matrix of the corundum of the Carnatic.[4] It is met with in small irregular masses and also in crystals, some brownish- or yellowish-green and nearly opaque, others translucent or nearly transparent, and of "a beautiful topaz yellow, which sometimes inclines slightly to green."[5] The following analyses are given by Chenevix,[6] which, however, can scarcely, perhaps, be accepted as accurate beyond question. The proportion of silica is higher, and that of lime lower, than in most analyses of epidote of a more recent date. The peroxide of iron is doubtless meant.

	Crystals with rough surface.	Striated crystals.	Transparent yellow fragments.
Silica	45	40·0	42·0
Alumina	28	25·0	25·5
Iron	11	11·5	14·0
Lime	15	21·5	16·0
	99	98·0	97·5

Along with the specimens of egeran, noticed above,[7] some fine pieces of epidote, from Karaola, 6 miles east-north-east of Tonk, were sent. The mineral, of a deep-green colour, occurs in a crystalline massive form, with large cleavage planes here and there. The best specimen weighs 6lb and is solid epidote, without admixture of other minerals.

Jadeite.—A stone, known in commerce as jade, is extensively worked in the Mogoung district of Upper Burma. According to Dr. Anderson, the mines, or rather pits, are in a valley 25 miles to the south-west of Meinkhoom, as many as 1,000 men being engaged in digging during certain seasons of the year. "The stone is found in the form of more or less rounded boulders, associated with others of quartz, &c., imbedded in a reddish-yellow coloured clay. The pits are not dug after

[1] R. B. Foote : Records, G. S. I., Vol. XIX, p. 100.
[2] R. B. Foote : Records, G. S. I., Vol. XIX, p. 107; see also Vol. XVIII, pp. 15, 29. *Ibid.*, Vol. V, p. 18.
[3] Page 46.
[4] Phil. Trans., 1802, p. 291.
[5] *Ibid*, p. 335.
[6] Page 93.

any particular plan, and none exceed 20 feet in depth. They occur all over the valley and at the base of the hill. The masses which are removed are of considerable size, and I saw some in the godown of a merchant at Rangoon so large that they required three men to turn them."[1] Mr. Theobald writes that "a block, considerably under a cubic yard, was some years since, in Rangoon, valued at £10,000, but found no buyers, though it is said £8,000 were offered by the Chinese for it."[2]

There are at present three specimens of Burmese 'jade' in the museum:—

(1) A block weighing 15lb, which was sent originally to the museum, by the local Burma committee, for transmission, as a sample of Burmese jade, to the Vienna exhibition of 1873. It was subsequently returned to Calcutta. The stone possesses a sub-crystalline texture, and is mottled in colour, some parts being white, others bright apple-green. Before the blowpipe it fuses easily and quietly (without intumescence). H. = 6·75. Sp. gr. = 3·24. The block alluded to by Mr. Theobald was similar in colour to this.

(2) A specimen from Mogoung, presented by Colonel Phayre, formerly chief commissioner of Burma. Crystalline texture. Colour, fusibility, and hardness similar to that of No. 1. Sp. gr. = 3·33.

(3) A specimen presented by Captain Hannay, from Burma (and presumably, like No. 1, from Mogoung, as no other mines in Burma are mentioned by Dr. Anderson). Granular, or finely-crystalline texture, nearly homogeneous or very slightly mottled greenish-gray colour. Fusibility and hardness like that of No. 1. Sp. gr. = 3·34.

That all three specimens are jadeite is shown by the specific gravity, fusibility, texture, hardness, and colour.

Dr. Anderson states that the greater portion of the Mogoung stone was formerly exported to Momien, in Yunan, and that a considerable amount still goes there. It is *possible*, therefore, that the specimens of jadeite from China, of which analyses have been published, were originally obtained in Burma. It appears, however, that there are 'jade' mines in Yunan also, as well as in other provinces of China.[3]

Axinite was discovered, by Mr. Griesbach, 7 miles west of Kándahár, and about 1½ south-east of Kokorán, on the top of the ridge which extends from the Kándahár range in a north-easterly direction. He de-

[1] Expedition to Western Yunan, p. 66.
[2] Natural Productions of Burma, 2nd edit., p. 14.
[3] R. Pumpelly: Smithsonian Contributions, No. 202, 1866, p. 116.

scribes the mineral as occurring in veins, up to two feet in thickness, in hippuritic limestone, which has been greatly altered by trappean and syenitic intrusions. Most of Mr. Griesbach's geological specimens were lost during the looting of the cantonments after the battle of Maiwánd, and amongst those recovered there is but one of the axinite. In this the mineral is crystalline massive, and in small indistinct crystals : it has a very pale pink and pinkish-white colour ; and contains some calcite intermixed.

Some years ago a specimen was sent to the museum, for determination, by a firm of jewellers in Calcutta, who wrote that it had been sent to them from Káshmir, where they believed the mineral (which proved to be purple-brown granular and crystallized axinite) was found in considerable quantities. No further information has been obtained.

Phlogopite.—Large masses of bronze-coloured mica, in plates of some size, have been found in dolomite, with serpentine, in the Bichi river, a stream which falls into the Rehr, near Singrauli, in South Mirzapur. The mica has not been analysed, but, from the rock in which it occurs, its colour, and the character of the rings shown with convergent polarised light, there is every reason to suppose that it is phlogopite.[1]

Biotite.—Dark brown or black (sometimes dark green) mica is a common constituent of the metamorphic and granitic rocks in many parts of India. In some cases it is the principal mica ; in others it is subordinate to muscovite. As no analyses, however, have been made, it is doubtful how much of such dark-coloured mica should be referred to biotite.

Very large crystals of dark brown (apparently) uniaxial mica are sometimes met with in the granite of Northern Hazáribágh, where they occur with still larger ones of muscovite. There is a portion of a crystal of the former kind, weighing about 10lb, now in the museum, which was obtained, by the writer, from an old mica quarry about a mile north of Gumji. "Splendid crystals of orthoclase and biotite" are said, by Dr. Stoliczka, to occur, in porphyritic gneiss, in the Sanju valley, some 90 miles west of Khotan[2] ; but the writer probably judged of the mica by colour only.

Muscovite is widely diffused as a constituent of the metamorphic and granitic rocks of India. Plates of considerable size are found in several parts of the empire.

Thus plates nearly a foot in length are found in some of the granite veins of Mysore, and furnish mica for painting on.[3] "In some parts of

[1] F. R. Mallet : Records, G. S. I., Vol. V, p. 20.
[2] Records, G. S. I., Vol. VII, p. 49.
[3] Mysore and Coorg Gazetteer, Vol. I, p. 20.

the Western Ghâts, and on the table-lands to the east," mica is found "in plates large enough for windows and lanterns."[1] Mr. Brough Smyth mentions "large plates" as occurring in some of the quartz veins traversing the metamorphic rocks of the Wynaad.[2]

In parts of Rájputána, according to Dr. Irvine, "very large tables of talc can be extracted."[3] There are plates up to 5 or 6 inches across in the museum, some of them of fair quality, from several localities in the Chattarbhaj hills, north-east of Tonk; and a plate measuring $10\frac{1}{2} \times 5\frac{1}{2}$ inches, from the Jaipur territory, was sent to the Colonial and Indian Exhibition of 1886. The quality was inferior to that of fair Hazáribágh mica.

The granite veins at Wangtu bridge, on the Sutlej, in the Punjab Himalayas, include crystals of mica, some of which are 5 or 6 inches across.[4] "A fine specimen of mica in large plates," from the Gurgaon district, was exhibited at the Lahore Exhibition of 1864.[5]

In the northern part of the Hazáribágh district, both metamorphic and transition rocks, but especially the latter, are penetrated by innumerable dykes and veins, as well as larger masses, of schorl-bearing granite. The rock is generally coarse in texture, and often highly so, containing large masses of quartz and felspar, crystals of tourmaline several inches across, and plates of muscovite up to a foot in diameter or more. The writer has seen plates (some of which are now in the museum collections) measuring 20 inches × 17 and 22 × 15, while he was informed by the miners that considerably larger ones are sometimes obtained. The unaltered mica generally has a smoke-brown, or reddish-brown, colour in plates of moderate thickness, and is highly transparent (ruby mica of commerce). Occasionally it is pale or olive green.[6]

Similar mica is found in portions of the Gya and Monghyr districts, bordering on Hazáribágh.

The following analyses of "a clear, slightly greenish-coloured, plate of potash mica" from Bengal, and of "a perfectly transparent, slightly greenish-coloured potash mica, large plates of which are sent commercially from the East Indies," are respectively due to S. Blau and L. Sipöcz.[7] It is almost certain that the first analysis, and probable that the second, is of mica from Hazáribágh or that neighbourhood, as all the mica ex-

[1] T. Newbold: Jour. Roy. As. Soc., Vol. VIII, p. 154.
[2] Report on Gold Mines of S.-E. Wynaad, pp. 5, 6, 37.
[3] Topography of Ajmere, p. 165. By talc mica is meant.
[4] F. R. Mallet: Memoirs, G. S. I., Vol. V, p. 169.
[5] B. Powell: Punjab Products, Vol. I, p. 42.
[6] F. R. Mallet: Records, G. S. I., Vol. VII, p. 40.
[7] Mineralogische Mittheilungen, 1873, p. 31.

ported from Bengal, and by far the largest proportion of that exported from India, is obtained there.

	Bengal. Sp. gr.=2·831	East Indies. Sp. gr.=2·830
Fluorine	·15	·12
Silica	45·57	45·71
Alumina	36·72	36·57
Ferric oxide	·95	1·19
Ferrous oxide	1·28	1·07
Magnesia	·38	·71
Lime	·21	·46
Lithia	·19	...
Soda	·62	·79
Potash	8·81	9·22
Water	5·05	4·83
	99·93	100·67

Greenish-gray, plumose, scaly mica is not uncommon in the Hazáribágh granite, and remarkably fine specimens are obtainable in some places, as in the Sakri river, 2 or 3 miles south of Gáwan.[1]

The component minerals of a gneiss from Mánbhum, composed of white milky oligoclase and white margarodite, in a matrix of ordinary quartz, have been examined by Mr. M. Ormsby. The mica yielded[2]—

Silica	45·60
Alumina	31·24
Ferric oxide	6·40
Lime	·24
Magnesia	·84
Potash	10·44
Soda	1·00
Water	3·60
	99·36

Lepidolite has been found in the granite of Hazáribágh, noticed above under muscovite. Although not widely distributed, the mineral exists in considerable quantity in some places. Half a mile south-west of Pihira (lat. 24° 38′, long. 85° 51′) there is a dyke, in some parts of which the granite is composed of white felspar, quartz, and irregular masses of lepidolite, occurring as a scaly aggregate, and varying in colour from violet-red to grayish violet. In other parts, the rock passes into *greisen*, composed of granular quartz with lead-gray and violet-gray lepidolite. Small black grains and crystals of tinstone are occasionally discernible in both varieties.

[1] Records, G. S. I., Vol. VII, p. 40.

[2] M. S. S.; Memoirs, G. S. I., Vol. XVIII, p. 105.

Lepidolite is also met with in a dyke a little south-east of the above locality; just north of Bhuládi (3 miles north-north-west of Pihira); and about a mile south of Manimundar (1½ miles south-east of Pihira), where the sides of a hillock are strewn with blocks, one of which was estimated to weigh about 8 cwt.[1]

The alkaline ingredients of the lead-gray lepidolite, from the *greisen* at Pihira, have been estimated with great care by Mr. M. Page, in the laboratory of the University of Virginia.[2] The analysis of 102 grammes gave—

Potash	8·595
Lithia	1·754
Soda	·609
Rubidium oxide	·070

A doubtful trace of cæsium was recorded as the result of spectroscopic observation, but no thallium was found.

Lapis Lazuli.—Found in Badakshán, and said to occur in Afghánistán and Biluchistán, but not known, with certainty, to occur in India. (Pt. III, p. 528.)

Indianite.—This granular form of anorthite was originally described by Count de Bournon, in 1802, as forming the matrix of corundum from the Carnatic.[3] Most, at least, of the specimens which passed through his hands were obtained in the Salem district, and as he does not specially mention any other locality in India, it may perhaps be inferred that they were all from that district. The greater portion of them was collected by M. Leschenault. The name 'indianite' was given by De Bournon in 1817, and, as pointed out by Dana, has priority over the term 'anorthite,' which was not proposed till 1823.

According to the author's description, the Carnatic indianite "is sometimes in masses of a loose and granulated texture, with very coarse grains, and pretty much resembles a coarse sandstone; at other times it has a closer texture, the grains being nearer each other, and less distinct, so as either to give it an appearance similar to the kind of marble known by the name of *coarse-grained saline marble*, or to that kind of prehnite which is composed of a mass of crystals confusedly aggregated. In this matrix the crystals of imperfect corundum[4] are dispersed in the same manner as those of felspar are dispersed in porphyry, or rather in certain granites which, besides the aggregated constituent parts belonging to that kind of rock, also contain crystals of

[1] F. R. Mallet: Records, G. S. I., Vol. VII, p. 43.

[2] Chemical News, 7th Sept. 1883, p. 109.

[3] Page 46.

[4] By imperfect corundum the author means corundum as distinguished from ruby sapphire, &c.

felspar which are of a more or less considerable size, and of a perfectly determined form.

"When this substance is of that texture in which the grains are closely connected together, it is of pearly gray colour, sometimes slightly tinged with green, and has a degree of semi-transparency, not unlike that of chalcedony. If a piece of this kind is moved about in a strong light, its surface shows a considerable number of small brilliant particles. This appearance arises from the reflection of the light, by the small laminæ that are exposed, in consequence of the fracture of the grains of which the stone consists; and this circumstance proves that it has a laminated texture. * * * This substance is more usually met with in pieces of a coarser texture, in which the grains are often pretty large, so as to be easily distinguishable by the naked eye. When these pieces are in a perfect state, the grains have exactly the same colour, and the same degree of semi-transparency, as those of the preceding more compact kind. If examined with a lens, the laminated texture of these grains is very evident; and there seems to be, at the first view, a very distinct crystal in each of them. But, if we endeavour to determine the form of any one of these crystals, we find that it is absolutely impossible to do so, as the greatest part of the small facets we perceive are nothing more than facets formed by compression. I thought, indeed, that I could distinguish some traces that indicated an obtuse rhomboid, but not in such a manner as to permit me to state the fact with certainty. These grains have but a weak degree of adherence to each other, in consequence of which the stone may often be broken by a very slight effort."

Some specimens were met with in which the indianite was very fine grained and almost compact. Again, it has been observed coarsely granular, and associated with black mica, quartz, and garnet, forming "a true indianite gneiss." In another gneissose variety the mica was replaced by hornblende.

The mineral scratches glass, but is scratched by felspar. Sp. gr. = 2·742. Does not become electric by friction. Colour usually grayish-white, but sometimes ash-gray, reddish-gray, or white; or, when coloured by intermixed hornblende, pale straw-yellow, greenish-yellow, or dark brown. Transparency doubtful, and generally, in the rock, little or none.[1] Lustre very slight. When struck with force emits a bluish-white phosphorescent light. Infusible before the blowpipe. When the mineral is quite unaltered, acids have no action on it, but when partly decomposed, which is frequently the case superficially, or when long exposed to the atmosphere, it effervesces more or less when placed in nitric acid.[2] On

[1] This does not agree with the preceding remarks.

[2] Phil. Trans., 1802, p. 282; Observations sur quelques-uns des minéraux, soit de l'Ile de Ceylan, soit de la côte de Coromandel, p. 23.

comparing the above description with that given below by Brush, it will be seen that they do not agree with reference to the action of acids, and the hardness of the mineral.

All the specimens of indianite received by De Bournon from India were in the granular form. The small crystals described by him[1] were in specimens obtained 3 miles north of Colombo. It is unnecessary to quote his remarks concerning these, as the primitive form he ascribes to them is manifestly incorrect. Brooke[2] observed two cleavages making angles with each other of 95° 15′ and 84° 45′. More modern works give these angles for anorthite (0P∧∞P∞) as 94° 10′ and 85° 50′.

The following analysis have been made of indianite :—

	Chenevix.[3]	Laugier[4] (Red).	Laugier[4] (White).	Brush.[5]	Oxygen.
Silica . . .	42·5	42·00	43·0	42·09	=21·869=4
Alumina . . .	37·5	34·00	34·5	38·89	=17·160=3
Ferric oxide . .	3·0	3·20	1·0		
Lime . . .	15·0	15·00	15·6	15·78	= 5·592=1
Soda . . .	...	3·35	2·6	4·08	
Water . . .	...	1·00	1·0	...	
	98·0	98·55	97·7	100·84	

The specimen analysed by Brush is described as "granular, and of a pink colour, sometimes gray or blackish, very tough and hard. Hardness = 7—7·25. Gravity = 2·668. It gelatinized completely in cold hydrochloric acid. Before the blowpipe alone infusible."

Captain Newbold says that "indianite occurs sparingly with corundum, fibrolite, and garnet, in gneiss and hornblende schist, in the valley of the Cauvery."[6] Whether the author alludes to the Salem district, where most of De Bournon's specimens were obtained, is uncertain.

Labradorite.—In how far the plagioclastic felspars of the eruptive (and metamorphic?) rocks of India should be referred to this mineral, is a point which has not been determined.

Oligoclase.—One of the most remarkable features in the geology of the North-West Himalayas is the "granitic axis, so persistent along the main range. To the east in Sikkim, and in the north-west, from the frontier of Nepál to Kulu, wherever examined, coarse white granite has been found in profusion along the line of peaks, near the present edge of the sedimentary basin of Tibet. It occurs in veins and dykes of every

[1] Observations sur quelques-uns des minéraux, &c., p. 21.
[2] Phillip's Mineralogy, 3rd edit. 1823, p. 44.
[3] Phil. Trans. 1802, p. 334.
[4] Mem. Mus. d'Hist. Nat., VII, 341 (as quoted in Dana's Mineralogy, p. 339. The present writer has not access to the original paper).
[5] Amer. Jour. Sci., 2nd Ser., Vol. VIII, p. 391.
[6] Jour. Roy. As. Soc., Vol. VIII, p. 153.

size, sometimes forming the massive core, up to the summit of the highest mountains." [1]

At Wángtu, on the Sutlej, from which the only sample of the felspar yet analysed was brought, the felspar is cleavable-massive, with twinning striations sometimes visible on the basal cleavage planes. The colour is milk-white, the mineral being translucent in moderately thin fragments. In general appearance it is somewhat like the cleavable-massive oligoclase from Ytterby, in Sweden, specimens of which are to be found in most mineral collections, but it differs from the latter in that striations are of comparatively rare occurrence.

Striated fragments afforded [2]—

		Oxygen ratio.
Silica	61·40	8·90
Alumina	23·48	3·04
Ferric oxide	·83	
Lime	3·23	1·00
Magnesia	·08	
Soda	10·07	
Potash	·75	
	99·84	

giving, therefore, the oxygen ratio for oligoclase [3] (9 : 3 : 1).

In how far the felspar of the above-mentioned granite, generally, is oligoclase, is not known. It appears from Colonel McMahon's microscopic examination of the Wángtu granite that, even there, "orthoclase and microcline taken together, equal, or nearly equal, the plagioclase." [4]

The felspar of a variety of gneiss occurring in Mánbhum [5] has been examined by Mr. M. Ormsby. The mineral is described as slightly translucent, with a milky appearance, and without any visible striæ. On analysis it yielded—

		Oxygen ratio.
Silica	64·20	10·04
Alumina	22·84	3·24
Lime	3·13	1·00
Magnesia	trace	
Soda	8·72	
Potash	·84	
	99·73	

giving an oxygen ratio approximating to that of oligoclase. Mr. Ormsby remarks on the unusual character of this gneiss in which the

[1] H. B. Medlicott: Pt. II, p. 629.

[2] F. R. Mallet: Records, G. S. I., Vol. XIV, p. 238.

[3] The Wángtu felspar has been erroneously described as albite in the Memoirs, G. S. I., Vol. V, pp. 12 and 169.

[4] Records, G. S. I., Vol. XVII, p. 58.

[5] *Vide* page 98.

above is the chief felspathic component.[1] The gneiss in many parts of India contains two felspars, the most abundant of which, however, is orthoclase. It generally occurs in larger crystals than the other, and is very frequently pink or red in colour, although sometimes white. The subordinate felspar is not a constant ingredient; it is always, as far as the writer's experience goes, white in colour, weathering with a dull opaque surface, from superficial alteration into kaolin, and on such altered face it is markedly different in appearance from the orthoclase, which weathers far less readily. The subordinate felspar often shows the striæ characteristic of plagioclase, but the only analysis that has been made gives an oxygen ratio intermediate between that of oligoclase and that of albite.[2]

Albite.—Twin crystals of "glassy shining albite, with a vitreous lustre," are said to occur, with quartz, mica, &c., in a porphyry having a paste of granular white opaque albite, from the Kaj Nag mountain, west of Baramula, in Káshmir. The crystals are sometimes as much as five inches long.[3]

According to Captain Newbold, "albite, or cleavelandite, occurs pretty abundantly in the gneiss of the Eastern ghâts above Bezwara, north of the Kistna, at Paddioor in Coimbatore, and occasionally through the gneiss districts of Southern India."[4]

The same author, in describing the old beryl mine at Paddioor, remarks that the dyke, in which the mineral occurs, is composed of "a highly crystalline porphyritic granite, the component minerals of which are generally beautifully characteristic and distinct. The quartz is sometimes regularly crystallized, but usually in amorphous translucent masses, imbedded in large tabular crystals of pale rose-coloured felspar, with cleavelandite, garnet, and white, black, and bottle-green mica. * * * The crystals of cleavelandite were remarkably fine, and characteristic of this beautiful variety of felspar. The various minerals composing this bed pass from the porphyritic structure into a curiously fibrous arrangement; the quartz, felspar, and cleavelandite occurring in alternate prismatic laminæ. * * * The felspar and cleavelandite is both white and translucent, and opaque and reddish. * * * The cleavelandite often occurs in large masses, with small cavities, partly formed by the decomposition of the rock, and partly by the intersection of the longer and more distinct crystals of the cleavelandite; it is in this gangue, and in these cavities, that the beryl, or aquamarine, is almost invariably found, in long deeply-striated hexahedral prisms, with small crystals of quartz."[5]

[1] MSS; Memoirs, G. S. I., Vol. XVIII, p. 44.
[2] Records, G. S. I., Vol. V, p. 19.
[3] A. Verchère: Jour. As. Soc., Bengal, Vol. XXXV, Pt. II, pp. 100, 101.
[4] Jour. Roy. As. Soc., Vol. VIII, p. 154.
[5] Madras Jour. Lit. and Sci., Vol. XII, p. 173.

Neither author mentions how the species of the felspar was determined. As shown in the sequel,[1] the felspar of the Bezváda gneiss is murchisonite, not cleavelandite; hence Captain Newbold's remarks on Paddioor, &c., also, must be received with some caution. There are, however, two specimens of white, translucent, lamellar, triclinic (striated) felspar in the museum labelled "cleavelandite, India," which agree in some respects with the mineral of Paddioor, as described by him, and they *may* be from that locality.

Orthoclase.—As a constituent of the gneissose and granitic rocks of India, orthoclase is a very widely diffused mineral, and occurs in great abundance in many places. The largest masses and crystals are found in some of the granitic rocks, and in the pegmatite veins (in many cases of segregitic origin) which traverse some of the metamorphic, especially the gneissose, rocks. In the Trichinopoly district, for instance, crystals, 4 or 5 inches in diameter, have been observed in one granite vein, while in another, crystals of immense size, sometimes as much as 2 feet × 2½, occur, and in a third there are still larger ones.[2] Large masses of orthoclase, with cleavage planes sometimes a foot long, are met with in some parts of the Hazáribágh granite, from which the muscovite previously noticed is obtained. The above are merely given as cases in point, out of many that might be quoted.

Orthoclase crystals, from the porphyritic granitic gneiss of Mánbhum have been analysed by Mr. Ormsby, with the following result[3] :—

		Oxygen ratio.
Silica	65·04	11·43
Alumina	19·60	3·01
Lime	·89	1·00
Magnesia	trace	
Potash	12·60	
Soda	2·48	
	100·61	

It has been remarked, by Mr. Bose, that orthoclase is of uncommon occurrence in the basic flows of the Deccan trap, and that it forms a normal constituent of certain trachytic rocks only.[4]

Of the rarer kinds of orthoclase :—

Adularia is said to occur, with asbestiform tremolite, and magnetite, in veins, through mica-schist or gneiss at Adepuram, in the Nellore District.[5]

[1] Page 105.

[2] W. King and R. B. Foote: Memoirs, G. S. I., Vol. IV, p. 336.

[3] *Ibid.*, Vol. XVIII, pp. 95, 104.

[4] *Ibid.*, G. S. I., Vol. XXI, p. 52.

[5] T. Newbold: Madras Jour. Lit. and Sci., Vol. XII, p. 28; Jour. Roy. As. Soc., Vol. VIII, p. 154.

The mineral is also stated to exist in considerable quantities in the district of Bangalore.[1] "Adularia-felspar," some crystals of which are 6 or 8 inches in length, has been found in a granite vein near Ramidi in Cuttack.[2] According to Dr. Irvine, "glassy felspar is common" (in Rájputána) : "a large mass of it protrudes through the ground, opposite the Dowlutbágh, on the road to the Anasagur bund," at Ajmere.[3] Adularia, perhaps, is meant. Mr. Hardie, again, mentions "veins of felspar, or rather adularia, with a beautiful pearly lustre" traversing granite near Bunera, in Meywar.[4] Near Biana, the same mineral is found, according to the same writer, in conglomerate, as previously noticed under chalcedony.[5]

Amazonstone.—See microcline.[6]

Murchisonite.—From Bezváda, on the Kistna, north-eastwards, and again in the Godávari and Vizagapatam districts, a peculiar form of gneiss has been traced, by Dr. King, which is characterized by the frequency of garnet as a constituent, and by the felspar being generally murchisonite. The rock is described, by Dr. King, as "generally of a dark brownish-red colour, and composed mainly of a bright, lustrous, well-cleaved, and occasionally foliated red felspar. It is rough and granular, but well foliated, or more or less schistose, or even fibrous and then somewhat silky, though it is never quite a schist; or again, tolerably massive. Sometimes the felspar predominates to such an extent that there are seams, and even thick beds, of what might be called a felspar rock, the murchisonite being then massive and granular. At other times the rock is more like a granite, with the felspar in largish crystalline masses; but usually when granitoid it is a coarse granular aggregate of felspar, less quartz, and a little mica. Garnets are very frequently distributed through it, often to such an extent that it may be called a garnetiferous gneiss, as at Bezváda, where the rock is often crowded with small crystals of bright red and purple colours, which are only wanting in size to render them beautiful and valuable stones. Here also, and in the Augurpali country, there is a good deal of graphite thinly scattered through the rock, giving at times graphite schists, or massive graphitic rock with graphite in minute scales.

"The felspar is generally reddish or of a pale salmon-colour, weathering lighter, but it is frequently of a decided red, even rosy red, and then, on well-worn and smoothed surfaces it has somewhat the look of rhodon-

[1] Mysore and Coorg Gazetteer, Vol. II, p. 3.
[2] W. T. Blanford : Memoirs, G. S. I., Vol. I, p. 37.
[3] Topography of Ajmere, p. 163.
[4] Edin. New Phil. Jour., Vol. VII, 1829, p. 121.
[5] Page 71.
[6] Page 107.

ite, while it has nearly always a fine pearly silvery or bright bronze sheen."[1] "Seams of almost pure white murchisonite" are occasionally found in the gneiss.[2]

The specimens of murchisonite sent by Dr. King, which are now in the museum, have two cleavages at right-angles to each other, on which the lustre is vitreous and the colour rather dark red, and a third cleavage, making an angle of about 104° with one of the above, and 90°, or nearly so, with the other. On this the lustre is strongly pearly, and the colour very much lighter. Heated with gypsum and examined with the spectroscope, the mineral shows the potassium red line. It fuses at about 5. Sp. Gr. = 2·55, H. = about 5. The inferiority of the hardness to that of ordinary orthoclase is perhaps due, in part, to incipient decomposition, but the translucency of the mineral in a direction parallel to the abnormal cleavage seems to indicate that it is not altered to any considerable extent. The hardness of the original murchisonite from Dawlish, in Devonshire, is described as "rather less than that of felspar," the abnormal cleavage (which has a pearly lustre) making an angle of 106° 50′ with the basal, and 90° with the clinodiagonal, cleavage.[3]

Hunterite.—Amongst a number of specimens collected near Nágpur, by the Rev. Messrs. Hislop and Hunter, and examined by Dr. S. Haughton,[4] was one from a pegmatite vein, traversing gneiss at right angles to the strike. It was obtained from a water-course between Mr. Hislop's house and the city. The components of the pegmatite were—

(1) Quartz of watery lustre.

(2) *Hunterite.*—White felspathic mineral of fatty lustre, softer than felspar, but gritty under the agate pestle.

(3) Pink felspar, in large tabular crystals (1 inch by ½ inch), with brilliant reflection.

The hunterite yielded on analysis :—

		Atomic ratio.[5]
Silica	65·93	1465
Alumina	20·97	403
Lime	·30	32
Magnesia	·45	
Loss on ignition	11·61	1290
	99·26	

Although the mineral presented no appearance of disintegration, its

[1] Memoirs, G. S. I., Vol. XVI, p. 207.
[2] Records, G. S. I., Vol. XIX, p. 151.
[3] Phil. Mag. Jan.-June, 1827, p. 448 ; Jan.-June, 1837, p. 170.
[4] Phil. Mag., Jan.-June, 1859, p. 18 ; Jan.-June, 1862, p. 50.
[5] Silica=SiO_3.

edges of separation from the pink felspar being well defined, Dr. Haughton recognised the possibility of its being altered orthoclase, but gave it as his opinion that it was an original constituent of the pegmatite, and proposed the name *hunterite* for it, as being a new mineral species.

"If," he writes, "we neglect the lime and magnesia, it may be regarded as having the following mineralogical formula:—

$$5\ (AlO_3, 3SiO_3 + 3HO) + (HO, 3SiO_3).^1$$

being, in fact, composed of five atoms of a hydrated tersilicate of alumina, combined with one atom of a hyaline silica of admitted composition. It appears to me to be a confirmation of this view of the mineral, that in the gneiss that accompanies the granite of Nágpur, and is often undistinguishable from it, this fatty felspar often passes into yellow and pinkish opalescent minerals, with which evidently it has the closest relation."

After suggesting an alternative formula, the author continues: "Whatever view be adopted as to the rational formula of this mineral, it is certain that part of its silica is in chemical combination with water; and if it be regarded as a metamorphic orthoclase, it is to be considered as one from which only $\frac{3}{3/2}$nds of the silica has been removed, and that the potash has been chemically replaced by water."

Microcline.—Amazonstone, passing into reddish orthoclase, has been found in a granite vein near the Trevellary Pagoda, in Trichinopoly.[2] Microscopic sections of it, as well as of amazonstone from the chord line of the East Indian Railway, show very plainly, in polarised light, the grating-like structure of microcline. "A felspar of a deep-green colour, in appearance approximating to the beautiful variety called amazonstone," occurs at Dodabetta, in the Nilgiris.[3] There is no specimen of this available for examination. But few of the felspars noticed under orthoclase have been examined very critically, and it is very likely that some of them should be referred to microcline.

That microcline is of common occurrence in many of the granitic rocks of India, may be inferred from the frequency with which it has been observed, by Colonel McMahon, in microscopic sections of such. Thus microcline is described as abundant in the granite of Tushám (about 80 miles west-north-west of Delhi), which also contains orthoclase and plagioclase.[4] Out of fifteen slices of "gneissose granite," from Dalhousie in the Punjab Himalayas, eight contained typical microcline, and in some

[1] $= 5\ (2Al_2O_3, 9SiO_2 + 6H_2O) + (2H_2O, 9SiO_2)$.

[2] W. King and R. B. Foote: Memoirs, G. S. I., Vol. IV, p. 336.

[3] H. Congreve: Madras Jour. Lit. and Sci., Vol. XXII, p. 249.

[4] The author uses the term 'plagioclase' as exclusive of microcline. Records, G. S. I., Vol. XVII, pp. 111, 112.

of them it was abundant. Orthoclase and plagioclase were also present. "In every slice in which typical microcline occurs, fibrous felspar is present. It also occurs in three slices in which the typical mineral is absent. The fibrous appearance is only observable in polarised light, and the felspar in which it occurs seems to me to be a form of microcline. In some an incipient cross-hatching can be made out; whilst in one, at least, it is distinctly visible in parts of the fibrous structure. * * * Many of the orthoclases and microclines contain the usual intergrowths of plagioclase and occasionally grains of quartz. Some of the microcline exhibits a tendency to inter-laminated structure resembling that of perthite, only it is finer grained and less pronounced. The intergrowth of felspar alluded to is quite distinct from the ordinary twinned structure."[1] Microcline was also observed, although more sparingly, in similar rocks from Chamba;[2] in the granite of Wángtu on the Sutlej,[3] where it is abundant; and of the Chor Mountain, south-east of Simla.[4] In all cases it is associated with plagioclase and orthoclase. Microcline has also been noticed, by the same writer, in a trappean rock from Rámpur, on the Sutlej.[5]

(*c*) Subsilicates.

Chondrodite occurs in white crystalline limestone at Mandalay hill in Upper Burma, as previously noticed under spinel.[6] The mineral has been found under exactly similar circumstances, at Ambasamoodrum, in the Tinevelly district.[7] There are specimens in the museum from both localities, in which the chondrodite, of a slightly-brownish yellow colour, is plentifully disseminated through the matrix.

Tourmaline.—*Rubellite.*—There are two magnificent specimens of this mineral, from Upper Burma, in the British museum collection. One of them was given by the king to Major Symes, when on an embassy to Ava in 1795. It measures about $5'' \times 6'' \times 6''$, and is described by Count de Bournon as "entirely composed of crystals placed by the side of each other in a diverging form, or rather penetrating each other at one of their extremities, and separating or diverging a little at the other extremity. Every one of these crystals, most of which are as long as the height of the specimen, is nearly as thick as the little finger. Their form is a hexahedral prism, which is deeply striated, and terminated

[1] Records, G. S. I., Vol. XVI, p. 130.
[2] *Ibid.*, Vol. XVIII, p. 80
[3] *Ibid.*, Vol. XVII, p. 58.
[4] *Ibid.*, p. 61.
[5] *Ibid.*, Vol. XIX, p. 73.
[6] Page 51; Pt. II, p. 708.
[7] Page 52.

by a trihedral pyramid with rhombic planes,[1] the angles of which measure exactly the same as those of the corresponding pyramid in the common tourmaline. All the crystals are pretty transparent, and terminate on the top of the specimen by the forementioned pyramids, but at different heights; a circumstance that gives to the top also a trihedral pyramidal form, but much less obtuse than that belonging to each crystal of which it is composed. The greatest part of this specimen is of a pale purplish-red, or flesh colour; but towards the base this colour grows much more deep, so that at last it becomes absolutely black." [2]

The other specimen, obtained from Ava, and presented by Mr. Guthrie in 1869, measures about 3″ × 3″ × 4½″ or 5″ high, and is a mass of slightly convergent columnar crystals, which vary in diameter up to about an inch, and are terminated by obtuse rhombohedrons, with the basal plane on some. The colour is a deep crimson, and the specimen, although smaller than Major Symes', is a much finer one, on account of its rich and uniform colour.

In De Bournon's collection were specimens of "flesh-red" tourmaline from "Pegu" [3] (Upper Burma ?).

Achroite.—Specimens of this variety, from the same locality as the rubellite, were included in the collection just mentioned. According to Dr. Mason, "An occasional crystal of white tourmaline is seen among the crystals of the black variety, in specimens from the Shan States." [4]

Indicolite, with green tourmaline, the latter being the more abundant, occurs in the granite of two dykes, south-west of Pihira, in Hazáribágh. These have been previously mentioned under lepidolite.[5] Some of the crystals approach an inch in diameter. Most of the smaller ones traverse, in a direction parallel to the cleavage, a silvery mica which is present as well as the lepidolite; others penetrate the quartz. Some of them are indigo-blue in the interior, and green externally. The mineral contains lithia, as might be expected from its association with lepidolite.

Indicolite has also been observed in association with the sapphire of Zánskar, as noticed below under brown tourmaline.

Green tourmaline is said, by Captain Newbold, to occur in the gneiss districts of Southern India, although not common. No localities are given.[6] "Needle-shaped crystals," of the same variety, are stated to have been found in a granite dyke traversing gneiss, in the bed of the Cauvery

[1] An obtuse rhombohedron.

[2] Phil. Trans., 1802, p. 317. The specimen was in Mr. Greville's collection when described as above.

[3] Catalogue de la Collection Minéralogique du Comte de Bournon, faites par lui-même, p. 69.

[4] Natural Productions of Burma, p. 35.

[5] Page 98.

[6] Jour. Roy. As. Soc., Vol. VIII, p. 154.

at Seringapatam.[1] The mineral found at Pihira has been noticed under indicolite. In De Bournon's collection, together with the rubellite previously mentioned, and from the same locality, were specimens of green tourmaline "of different shades, including a fine emerald green."

Yellow and brown tourmaline.—In the collection just alluded to were also yellowish tourmalines, from the same province as the rubellite. The brown tourmaline, which is associated with the sapphire of Zánskar, has been noticed in connection with the latter.[2] There is a small transparent crystal in the museum, which was implanted on the wall of a cavity in the centre of a crystal of sapphire. It shows the faces ∞P2. ∞R. R., and is light brown in colour, except at the termination, which is indigo-blue.[3]

Schorl is extremely common in many of the granitic, metamorphic, and transition rocks. In some cases it forms a constant constituent, not merely an accidental mineral. Thus, the granite of Hazáribágh[4] is a quaternary compound in which the crystals of schorl occasionally exceed 6 inches in diameter. The most ordinary combination is ∞P2. ∞R. terminated at one end by R.[5] and at the other by R.—2R. The granite which traverses the Arvali (transition) beds of Rájputána, in innumerable dykes, is a similar compound, in which schorl is seldom entirely absent, and is usually very abundant.[6] Schorl is also plentiful in much of the granite which penetrates the gneissose rocks of the Punjab[7] and Sikkim[8] Himalayas, and is, further, a very common ingredient of the gneiss itself. It is plentiful in the Arvali limestones of Rájputána;[9] in the metamorphic quartzites of the Chundi hills, in Nellore;[10] and frequently occurs in the transition schists, as well as in the quartz veins which traverse older rocks.

Allusion may here be made to the frequency with which tourmaline occurs in association with corundum. It is found with the granular corundum of South Rewah;[11] in talcose schist, containing crystallized corundum, in Mysore;[12] and with the sapphires of Zánskar:[13] whether the red tourmaline of Burma is found in connection with the rubies, is

[1] Mysore and Coorg Gazetteer, Vol. I, p. 20.
[2] Page 41.
[3] Records, G. S. I., Vol. XV, p. 139.
[4] F. R. Mallet: Records, G. S. I., Vol. VII, p. 39.
[5] R ∧ R = 133° 8′.
[6] C. A. Hacket: Records, G. S. I., Vol. XIV, p. 283.
[7] F. R. Mallet: Memoirs, G. S. I., Vol, V, p. 171.
[8] J. D. Hooker: Himalayan Journals, Vol. II, p. 27.
[9] C. A. Hacket: Records, G. S. I., Vol. X, p. 85.
[10] R. B. Foote: Memoirs, G. S. I., Vol. XVI, p. 16.
[11] Page 48.
[12] T. Newbold: Jour. Roy. As. Soc., Vol. VII, p. 222.
[13] Page 41.

not yet known. The same association has been noticed by Dr. J. L. Smith with reference to the emery of Naxos, and of Chester, in Massachusetts.[1]

The name 'tourmaline' is commonly said, and doubtless correctly, to be derived from a Cingalese word; but, as was pointed out by Mr. Prinsep more than fifty years ago, *turmali* is the name applied by the native jewellers of Ceylon to *zircon*[2]—a fact which has also come within the writer's experience, with reference to the zircons which have been decolourized by heat, and which are known in English as Ceylon or Matura diamonds. There has evidently been some confusion between the two minerals. Coloured tourmaline is said to occur in Ceylon as well as zircon, and if this be correct, it is possible that *turmali* is the name used for both minerals by the natives, who may not clearly distinguish between them. But it seems quite as likely that the word in question, which according to Professor Dana was introduced into Holland in 1703, has been misapplied by Europeans.

Andalusite has been met in the metamorphic rocks of Mánbhum,[3] and in the transition schists of South Mirzapur. Rather fine crystals have been observed near Dudhi, in the latter district. The Arvali schists of Rájputána are described by Mr. Hacket as containing crystals of andalusite, staurolite, and garnet in abundance.[4]

Chiastolite schist has been noticed, by Colonel McMahon, in the Tushám Hills, about 80 miles west-north-west from Delhi.[5] The same rock is described by Dr. Mason as occurring to the east of Tavoy, in Tenasserim.[6]

Fibrolite.—The name of this mineral is due to Count de Bournon, by whom it was observed as an associate of corundum from the Carnatic, in the indianite matrix previously alluded to.[7] He describes it as either white, or dirty gray, in colour; rather harder than quartz; infusible before the blowpipe; and with a specific gravity of 3·214. "The external texture of this substance is usually fibrous, the fibres being very fine, and closely connected together. When it is broken according to the direction of the fibres, its internal texture appears to be exactly the same; but, if it is broken in a direction transverse to the fibres, its texture appears to be compact. The lustre of this last kind of fracture is rather vitreous, and there is nothing in its appearance that gives

[1] Amer. Jour. Sci., 2nd Ser., Vol. XLII, p. 92.
[2] Jour. As. Soc. Bengal, Vol. I, p. 357.
[3] V. Ball: Memoirs, G. S. I., Vol. XVIII, p. 43.
[4] Records, G. S. I., Vol. X, p. 85.
[5] *Ibid.*, Vol. XVII, p. 106.
[6] Natural Productions of Burma, p. 35.
[7] Page 46.

reason to think it was made in the direction of the laminæ. When we wish to try the hardness of this stone, it should be done in a direction which is transverse or perpendicular to the fibres, not in a direction parallel to them. There exist many pieces of this substance that are merely irregular aggregations, in which the fibres cross each other, in bundles, in different directions." [1]

The following analyses have been made of specimens from De Bournon's cabinet :—

	Chenevix.[2]	Silliman.[3]
Silica	38·00	36·309
Alumina	58·25	62·415
Ferric oxide	trace	...
Magnesia	...	·702
	96·25	99·426

Fibrolite is said to have been observed in the metamorphic rocks of Mánbhum.[4]

Kyanite is a common mineral in some of the metamorphic rocks of India. In some parts of the gneiss [5] and mica schists [6] of the North-Western Himalayas, for instance, it occurs in abundance, and extremely fine specimens are sometimes met with. There is one now in the museum, from Chini, on the Sutlej, composed of a number of aggregated blades which are individually more than 9 inches long. Other specimens from the same region are blue along the centre of the blades, and greenish on the margins. The same mineral is also of frequent occurrence in the granite veins which penetrate the above-mentioned rocks.[7] It is often met with in the gneissose rocks of the Sikkim Himalayas,[8] and has been found in those of Chutia Nágpur.[9]

Mr. Foote has described the occurrence of bands of mica schist, in the gneiss of the Chundi hills in Nellore, which contain abundance of kyanite and staurolite; the minerals in some instances occurring together, in others separately.[10] There are specimens, from that region, in the museum collection, formed of blades three quarters of an inch

[1] Phil. Trans., 1802, p. 289.
[2] *Ibid.*, page 335.
[3] Amer. Jour. Sci., 2nd Ser., Vol. VIII, p. 388.
[4] V. Ball: Memoirs, G. S. I., Vol. XVIII, p. 43.
[5] F. Stoliczka: Memoirs, G. S. I., Vol. V, p. 14; C. H. McMahon, Records, G. S. I., Vol. X, p. 219.
[6] T. Thomson: Western Himalaya, pp. 84, 111.
[7] R. Strachey: Q. J. G. S., Vol. VII, p. 302.
[8] F. R. Mallet: Memoirs, G. S. I., Vol. XI, p. 43.
[9] M. Stœhr: Records, G. S. I., Vol. III, p. 87; V. Ball, Memoirs, G. S. I., Vol. XVIII, p. 43.
[10] *Ibid.*, Vol. XVI, p. 15.

broad and 5 inches long. Kyanite has also been observed in the gneissose rocks of Hyderabad, Mysore, and some other parts of Southern India.[1]

Rhætizite has been noticed in the schistose rocks of Singhbhum,[2] and occurs, although but rarely, associated with ordinary kyanite, in the gneiss of the Yangpa valley, above Wángtu on the Sutlej, in the North-Western Himalayas.[3]

Topaz is said to have been found in the bed of the Máhanadi,[4] and Dr. McClelland has stated that it occurs "indrusal cavities in trap," at Chumpar hill, about 6 miles north-east of Dubrajpore, in the Rájmahál hills.[5] The mineral, from the latter locality at least, is most probably yellow or smoky quartz.

Sphene has been observed, by Colonel McMahon, in microscopic sections of trap, diorite, and hornblende rock from the Sutlej valley;[6] of diorite, from Hundes, in Tibet;[7] of felsite from Maláni, in Rájputána;[8] and of potstone from Dhálbhum.[9]

Tscheffkinite.—A substance brought from India by M. Leschenault (who has been previously mentioned in connection with indianite) was described by Beudant under the name of "minéral de Coromandel." The edition of his mineralogy of 1832, in which the description is given, is, however, not accessible to the writer. It contains the following analysis by Laugier:[10]—

Silica	19·00
Titanic acid	8·00
Oxide of cerium	36·00
Oxide of iron	19·00
Oxide of manganese	1·20
Lime	8·00
Water	11·00
	102·20

[1] T. Newbold: Jour. Roy. As. Soc., Vol. VIII, p. 153.
[2] M. Stœhr: Records, G. S. I., Vol. III, p. 87.
[3] Memoirs, G. S. I., Vol. V, p. 171.
[4] Select. Rec. Govt. Bengal, No. XXIII, p. 184.
[5] Report of the Geological Survey for 1848-49, p. 51.
[6] Records, G. S. I., Vol. XIX, pp. 73, 76, 78.
[7] *Ibid.*, page 119.
[8] *Ibid.*, page 162.
[9] *Ibid.*, Vol. XX, page 44.
[10] As quoted by Damour, Bulletin de la Soc. Géol. de France, 2d Ser., Vol. XIX, p. 550. The analysis as quoted by Dana (System of Mineralogy, p. 388) gives the iron and manganese as sesquioxides. Coromandel is erroneously placed in Africa in the latter work.

The substance was re-examined by Damour in 1862,[1] who was put in possession of one of Leschenault's original specimens for the purpose. He writes that "the mineral of Coromandel forms an amorphous mass, of a brownish-black colour, translucent only in the thinnest splinters. The powder is brown. The mineral quite resembles allanite and orthite in external appearance. Scratches glass. Sp. gr. = 4·26. Before the blowpipe melts, with intumescence, to a slightly magnetic black scoria. With salt of phosphorus it gives a pale-brown opaline glass in the reducing flame, which becomes milky white in the oxidising flame.

"With borax, it gives a dark, hyacinth-brown, transparent glass in the reducing flame, which becomes pale brown and opaque, in the oxidising flame.

"When heated in a closed tube, it gives off a little water.

"Nitric acid attacks it easily, especially when heated, leaving a residue of gelatinous silica, mixed with titanic acid, and some black grains (titanic iron) which remain unaffected. The nitric acid solution gives an abundant precipitate with oxalic acid.

"On analysis the substance yielded—

		Oxygen ratio.
Silica	19·03	9·88 = 1
Titanic acid	20·86	8·32 = 1
Cerous oxide	38·38	
Ferrous oxide	7·96	
Lime	4·40	8·76 = 1
Magnesia	·27	
Manganous oxide	·38	
Alumina	7·72	
Water and volatile matter	1·30	
	100·30	

"I do not clearly see the part that the small quantity of alumina plays. Taking the other constituents, only, into account, the mineral seems to form a silico-titanate of cerium, iron, lime, &c., in which the oxygen of the silico, of the titanic acid, and of the bases, approximates to the ratio 1 : 1 : 1. It may be supposed that an amorphous material, and one so complex, does not show a very exact ratio between its constituents. We may conclude, however, from the results given, that the mineral of Coromandel belongs to the species that Rose found in the Ural mountains, and that he has described under the name of tscheffkinite."

Dana suggests the formula $(\frac{2}{5}\dot{R}^3 + \frac{1}{5}\dddot{R} + \frac{2}{5}\ddot{R}\,\frac{3}{2})^4\,\ddot{S}i^3$, and adds that

[1] *Op. cit.*

"Damour has made a new examination of the mineral, and directly ascertained the *absence of thorium*; he further observes that a little Di and La are probably presentwith the Ce. Descloizeaux states that the mineral is not homogeneous, it consisting of a brown material not acting on polarised light, and small colourless grains which are strongly doubly refracting. The mineral has H. = 5·5—6; G. = 4·26; lustre vitreous, inclining to resinous; colour brownish black; subtranslucent." [1]

There is a specimen of tscheffkinite in the British museum, labelled "Kantamala, Coromandel, India." The writer has been unable to trace the exact position of Kantamala. It is possible that the tscheffkinite was found in the same region as the specimens of indianite collected by M. Leschenault, which he obtained in the Salem district. Although Salem is inland, it is spoken of as "on the coast of Coromandel" by De Bournon, through whose hands the specimens of tscheffkinite may have passed, as well as those of indianite.

Staurolite.—The mica schists of the Chundi (or Sundi) hills, in Nellore, are described as being in many parts thickly crowded with staurolite crystals, often associated with kyanite. The crystals are generally of large size, 2 to 3 inches long, by $1\frac{1}{4}$ to $1\frac{3}{4}$ in width, and even larger ones (as well as smaller) are met with. The large crystals are almost invariably of coarse texture, and much covered with a film of mica. Some of the smaller ones have a fair amount of lustre. In various damp spots the weathered crystals get covered with a shining ferruginous coating, and pass gradually into a species of lateritic concretion.[2]

Specimens in the museum, from the above-named hills, include simple crystals showing the combinations ∞P. $\infty \breve{P}\infty$. $0P$. and ∞P. $\infty \breve{P}\infty$. $0P$. $\bar{P}\infty$. and cruciform twins (with and without $\bar{P}\infty$) with the composition faces $\frac{3}{2}\breve{P}\infty$ and $\frac{3}{2}P\frac{3}{2}$.

Staurolite has also been observed in the maritime districts of the Godávari and Kistna, and near Rayakota in Salem [3]; it is described as abundant in the Arvali schists of Rájputána, with andalusite and garnet;[4] and has been noticed in the mica schists of Házaribágh.[5]

Appendix to Anhydrous Silicates.

Bombite.—This name was given by De Bournon to a substance found near Bombay [6] and brought to Europe by M. Leschenault. It is de-

[1] System of Mineralogy, p. 388.
[2] R. B. Foote: Memoirs, G. S. I., Vol. XVI, p. 15.
[3] T. Newbold: Jour. Roy. As. Soc., Vol. VIII, p. 153.
[4] C. A. Hacket: Records, G. S. I., Vol. X, p. 85.
[5] *Ibid.*, Vol. VII, p. 39.
[6] There is some confusion about the locality, which is said to be "near Bombay" and "on the coast of Coromandel." A mineral found near Bombay would necessarily be from the Deccan trap, or intertrappean beds.

scribed as amorphous, of a very dark blackish-gray, and perfectly resembling Lydian stone in colour and outward appearance. The texture is very even and fine; fracture slightly conchoidal. Sp. gr. = 3·213. H. slightly above 7. Perfectly opaque except in the very thinnest splinters, which are slightly transparent on their edges, showing a bluish-gray colour. Before the blowpipe it melts very easily and quickly, with slight intumescence, to a slightly transparent brown-yellow glass. Insoluble in acids.[1]

Laugier's analysis [2] gave—

Silica	50·00
Alumina	10·50
Oxide of iron [3]	25·00
Magnesia	3·50
Lime	8·50
Carbon	3·00
Sulphur	·30
	100·80

The substance "has no definite chemical composition or form, but occurs in rounded fragments or amorphous masses, derived apparently from some old formation." [4]

B.—Hydrous Silicates.

I.—General Section.

(*a*) *Bisilicates.*

Dysclasite (Okenite).—"This mineral is found at Poona, in cavities of the amygdaloidal trap, in nodular masses, formed of smaller spheroidal concretions of radiated structure, and is characterized by extraordinary toughness, from which its name was originally derived." [5]

The author quoted obtained on analysis :—

		Oxygen ratio.	
Silica	54·24	28·93	= 4
Lime	27·44	7·84	= 1
Soda	·07	·02	
Water	17·04	15·15	= 2
	98·79		

[1] Observations sur quelques-uns des minéraux, soit de l'Ile de Ceylan, soit de la côte de Coromandel, p. 30.

[2] Traité de Minéralogie, by A. Dufrénoy, Vol. III, p. 523 (as quoted in Dictionnaire des analyses chimiques, p. 164 : the present writer has not access to the first-named work).

[3] In Bristow's Glossary of Mineralogy the iron is given as peroxide.

[4] *Op. cit.*

[5] S. Haughton : Jour. Roy. Geol. Soc. Ireland, New Series, Vol. II, p. 114.

Laumontite is described, by Dr. Blanford, as one of the more abundant zeolitic minerals of the Deccan trap,[1] although it is not found in such profusion as stilbite, apophyllite, and heulandite. Fine crystals from Poona[2] are contained in the British museum collection. Laumontite, associated with apophyllite and stilbite, and with scolecite, stilbite, and glauconite, from the Western Ghâts (Bhor or Thul ghât), is represented by specimens in the geological museum in Calcutta. Laumontite containing small spheroids of prehnite scattered through it, and also penetrating calcspar, is said to occur at Mazagon, Bombay.[3] In the collection just mentioned there are specimens of the mineral, collected by Mr. Fedden, from Lunidhar, and east of Jasdan, in Káthiáwar.

Chrysocolla has been occasionally noticed, in association with other ores of copper, as at Ganmanipenta, in Nellore ;[4] but no very remarkable occurrences of the mineral seem to have been recorded.

(*b*) *Unisilicates.*

Prehnite is one of the rarest minerals of the Deccan trap.[5] It is said to occur, with laumontite, as noticed under the latter mineral, at Mazagon, Bombay. According to Dr. Leith, prehnite has been found at Nowrojee Hill, in Mazagon ;[6] perhaps the same spot as that in which Malcolmson's specimens were obtained. In the museum there is but one example of the mineral, a rolled pebble from the bed of the Narbada.

The only locality, beyond the Deccan trap area, from which prehnite has been reported, is near Ajmere, where it is said to occur "in hornblende."[7]

Apophyllite.—The Deccan trap has long been noted for the profusion in which this mineral is found, and the magnificent crystals in which it occurs. In no other part of the world have equally fine ones been obtained.

It is only in certain portions of the trappean area that the mineral is found. The best known localities are Poona, where splendid specimens were brought to light during the sinking of wells,[8] and the Western Ghâts, in which magnificent crystallizations were obtained in abundance during the construction of the Bhor and Thul ghâts, on the

[1] Records, G. S. I., Vol. V, p. 90; Memoirs, G. S. I., Vol. VI, p. 141; Manual, Pt. I, p. 309.

[2] W. H. Sykes: Trans. Geol. Soc., 2nd Ser., Vol. IV, p. 425.

[3] J. G. Malcolmson: Jour. As. Soc., Bengal, Vol. XII, p. 1026; Vol. XIII, xxxvii.

[4] Records, G. S. I., Vol. XII, pp. 169, 171.

[5] W. T. Blanford: Records, G. S. I., Vol. V. p. 90; Manual, Pt. I, p. 305.

[6] Jour. Bom. As. Soc., Vol. VI, p. 180.

[7] R. Irvine: Topography of Ajmere, p. 162.

[8] W. H. Sykes: Trans. Geol. Soc., 2nd Ser. Vol. IV, p. 425.

Great Indian Peninsular Railway. A very fine series of specimens, from the latter places, is exhibited in the British museum, and almost equally good ones, obtained by Mr. Blanford, are included in the Calcutta collections. No doubt cuttings in many other parts of the area would unearth crystals as fine as those from the localities mentioned.

The apophyllite occurs in crystals, lining cavities in the amygdaloidal traps which are sometimes 2 or 3 feet across, and even larger drusy cavities are said to have been broken into.[1] The mineral is very commonly associated with stilbite in large crystals, and frequently also with scolecite, heulandite, calcite, quartz, &c.

"The colour of the Deccan apophyllite is usually white, more rarely pink or green; some crystals are perfectly transparent, and one of the most magnificent associations of minerals to be found anywhere is seen when, as occasionally happens, perfectly clear vitreous crystals of apophyllite, of large size, are inserted on a mass of orange stilbite. Some apophyllite crystals are as much as 3 or 4 inches across." [2]

There are two main types of crystal, that in which the basal planes are prominently developed, and that in which they are nearly or quite obliterated. The most characteristic variety of the first type is that in which the crystals assume a quasi-cubic appearance, from the planes 0P and $\infty P\infty$ being about equally developed while P is comparatively small (fig. 22). Crystals with P. more prominent are also common (fig. 23), and not unfrequently the face ∞P is present (fig. 24), sometimes accompanied by ∞Pm ($\infty P2$ or $\infty P3$?). But, in such specimens as have come under the writer's eye, these latter faces are almost microscopically small. More rarely the crystals are tabular, as in fig. 25. The preceding figures represent crystals in the museum from the Western Ghâts. Fig. 26, with $\infty P2$, and fig. 27 with $\frac{1}{3}P$, represent crystals from Poona, as figured by Schrauf.[3]

Crystals of the above type "are sometimes serrated all over on the basal plane by oscillatory combination of the apices of pyramids. When a ditetragonal prism enters into the combination, the faces of the secondary prisms are generally striated vertically." [4]

The crystals of the second type, which are less common and generally much smaller than those of the first,[5] have P as the predominant face. 0P is small (fig. 28) or entirely absent (fig. 29). Sometimes $\infty P\infty$ approaches extinction also, but in other cases, as in the crystal figured by Schrauf [3] (fig. 30), it is well developed and is accompanied by $\infty P2$.

[1] W. T. Blanford: Pt. I, p. 305.
[2] *Ibid.*, p. 306.
[3] Atlas der Krystall-formen des Mineralreiches.
[4] H. Bauerman: Text-Book of Descriptive Mineralogy, p. 249.
[5] W. T. Blanford: Pt. I, p. 306.

According to Dr. Haughton's measurements, the angle 0P. $\wedge$P. = 120° 20′, and P. $\wedge$P. = 103° 30′, which respectively give a value for the vertical axis of 1·208 and 1·281, on a mean of 1·2445.[1]

The Deccan apophyllite has been analysed by Dr. Haughton with the following result[2] :—

Silica	51·60
Alumina	·24
Lime	25·08
Magnesia	·08
Soda	·63
Potash	5·04
Water	16·20
Fluorine	·97
	99·84

(*c*) *Subsilicates.*

Allophane.—Some years ago two specimens from the Deputy Commissioner of Simla, and presumably, therefore, obtained in the Punjab Himalayas, were sent to the museum for determination. Both were allophane, one a pale sky-blue in colour, and the other partly green; the colour in both cases being due to a small proportion of copper. No information was obtainable as to how or where they were found.

II.—Zeolite Section.

(*a*) *Unisilicates.*

Thomsonite is one of the rarer zeolites found in the Deccan trap. According to Captain Newbold, it has been observed on the plain of Bijapur; in the Sholapur country; and in the Narbada valley.[4] There is a specimen from Serur, in the Ahmadnagar district, in the British museum.

Mesole was obtained, by Dr. Thomson, on the island of Caranja, in Bombay harbour, where, as well as in Salsette, it appears to occur in considerable abundance, in amygdaloid. He found the specific gravity = 2·262. Heated alone before the blowpipe, the mineral curls up, and, with

[1] Jour. Roy. Geol. Soc. Ireland, 2nd Ser., Vol. II, p. 113.

[2] Jour. Roy. Geol. Soc. Ireland, 2nd Ser., Vol. I, p. 252; Phil. Mag., 4th Ser., Vol. XXXII, p. 223.

[3] W. T. Blanford: Pt. I, p. 305.

[4] Jour. Roy. As. Soc., Vol. IX, p. 38.

borax, fuses with difficulty to a colourless bead. On analysis it yielded :[1]—

Silica	42·70
Alumina	27·50
Lime	7·61
Soda	7·00
Water	14·71
	99·52

Natrolite is mentioned by Newbold as found in the trap of the Deccan,[2] and by Voysey as occurring in the same rock in the Gawilgarh hills.[3] Professor Hubbard, of Dartmouth College, records having received specimens of natrolite "in hemispheres 7 inches in diameter; also in sectors of 3 inches radius, and of the most beautiful lustre and whiteness," from Ahmadnagar, a town in the midst of the Deccan trap area. They were sent by the Rev. Mr. Burgess, a missionary of that place.[4]

Natrolite is also said to occur in the Rájmáhal trap, where it is found in minute acicular crystals.[5]

Scolecite is described as one of the more abundant zeolites of the Deccan trap, although less common than some others. Remarkably fine specimens have been obtained from the tunnels and cuttings at the Bhor ghát: in these the mineral is associated with apophyllite and stilbite, and occurs in groups of radiating and divergent, transparent, and semi-transparent, colourless crystals, some of which are over 3 inches longer and nearly half an inch across; although, as a rule, they are thinner in proportion to their length. Of a fine series in the museum, only one or two crystals possess natural terminations, and those in positions when they do not admit of measurement.

The following analyses of the mineral have been published :—

	I.	II.	III.	IV.
Silica	46·87	45·80	45·90	46·91
Alumina	25·32	25·55	26·10	26·03
Lime	13·80	13·97	14·71	13·33
Soda	·45	·17	·09	·22
Potash	·13	·30	...	·08
Water	13·46	14·28	13·68	13·83
	100·03	100·07	100·48	100·40

[1] Edin. New Phil. Jour., Vol. XVII (1834), p. 186. The mineral is described by the author as mesolite, but, as shown by Dana, the composition is that of mesole.

[2] Jour. Roy. As. Soc., Vol. IX, p. 38.

[3] Asiatic Researches, Vol. XVIII, Pt. I, p. 190.

[4] Amer. Jour. Sci., 2nd Ser., Vol. XI, p. 424.

[5] T. Oldham: Jour. As. Soc. Bengal, Vol. XXIII, p. 270; Memoirs, G. S. I., Vol. XIII, p. 215.

No. I, from the "East Indies," consisted of "globular masses 5 to 6 inches in diameter of radiated structure. Sometimes there was found between the radii, which have a vitreous lustre, the same mineral of a reticulated structure with pearly lustre. B. B. it fuses with intumescence easily to a blebby glass." [1]

No. II, from the Western Ghâts; sp. gr. = 2·28.[2]

No. III was in bundles of long, needle-shaped, semi-transparent crystals, associated with apophyllite. From near Poona.[3]

No. IV. Bundles of white, to transparent, crystals, sometimes over an inch long, with a glassy to silky lustre. Sp. gr. = 2·296. Associated with apophyllite. From Poona.[4]

Poonahlite.—This name was originally given by Brooke to specimens of zeolite from Poona, which he considered as belonging to a new species, on the ground that the angle $\infty P \wedge \infty P$ was equal to 92° 20′, and therefore different from that of "mesotype or needle-stone." [5] Kenngott makes the angle = 91° 49′, the corresponding angle in scolecite being generally given as = 91° 35′ or 91° 36′. Brooke describes the crystals as slender, and traversing the mass of the associated apophyllite and matrix instead of forming groups in the cavities. Among several hundred crystals examined, not one had a natural termination. Specimens in the British museum, from Poona, are composed of groups of thin (almost acicular) divergent crystals, associated with stilbite and apophyllite.

Gmelin found the sp. gr. = 2·1622, and obtained by analysis[6]—

	Found.	Calculated.
Silica	45·120	45·07
Alumina	30·446	31·33
Lime	10·197	10·43
Soda, with trace of potash	·657	...
Water	13·386	13·17
	99·806	100·00

from which he deduces the formula

$$3(CaO.SiO_3) + 5(AlO_3.SiO_3) + 12H_2O$$

while he regards that of scolecite as

$$3(CaO.SiO_3) + 3(AlO_3.SiO_3) + 9H_2O$$

[1] W. J. Taylor: Am. Jour. Sci., 2nd. Ser., Vol. XVII, p. 410.
[2] P. Collier: Dana's System of Mineralogy, p. 429.
[3] S. Haughton: Jour. Roy. Geol. Soc. Ireland, 2nd Ser., Vol. II, p. 114.
[4] T. Petersen: Neues Jahrbuch für Min., 1873, p. 852.
[5] Phil. Mag., Vol. X (1831), p. 110.
[6] Poggendorff's Annalen, Vol. XLIX, p. 538.

These are equivalent to

$$3(2CaO.3SiO_2) + 5(2AlO_3.3SiO_2) + 24H_2O = Ca_3Al_5Si_{12}O_{42} + 12\,H_2O,$$

and

$$3(2CaO.3SiO_2) + 3(2AlO_3.3SiO_2) + 18H_2O = Ca_3Al_3Si_9O_{30} + 9H_2O.$$

Mesolite.—There are specimens of this zeolite in the British museum collection, from the Bhor ghát. In one of them the mineral occurs in thin, almost acicular, divergent prisms; others consist of a felt-like aggregation of microscopically slender crystals.[1]

Harringtonite also occurs in the Deccan trap. A specimen from the Bombay presidency, with sp. gr. = 2·174, and described as occurring "in large massive nodules, filling cavities in trap, of feathery structure," has been analysed by Dr. Haughton, with the following result[2]—

Silica	45·60
Alumina	27·30
Magnesia	trace
Lime	12·12
Soda	2·76
Potash	·63
Water	12·99
	101·40

(*b*) *Bisilicates.*

Analcime is said to have been found in the Deccan trap of the Poona district,[3] the Western Ghâts,[4] and the Gawilgarh hills,[5] but the mineral would appear to be one of the rarest zeolites, and was never met with by Mr. Blanford, who examined a very large area occupied by the rock in question.[6]

Analcime is also stated to occur, in small transparent crystals, in the trap of the Rájmahál hills.[7]

Chabasite is described as one of the rare zeolites of the Deccan trap.[8] It is said to have been found in the Poona district,[9] and at Nowrojee hill, in Mazagon, Bombay.[10] Malcolmson remarks that "beautiful specimens abound in certain localities of the western portion of the formation"[11]; but as this statement is without confirmation by other

[1] As previously noted, the mesolite of Dr. Thomson is mesole.

[2] Jour. Roy. Geol. Soc. Ireland., 2nd Ser., Vol. I, p. 254; Phil. Mag., 4th Ser., Vol. XXXII, p. 225.

[3] W. H. Sykes: Trans. Geol. Soc., 2nd Ser., Vol. IV, p. 425.

[4] T. Newbold: Jour. Roy. As. Soc., Vol. IX, p. 38.

[5] H. W. Voysey: Asiatic Researches, Vol. XVIII, Pt. I, p. 191.

[6] W. T. Blanford: Memoirs, G. S. I., Vol. VI, p. 141.

[7] T. Oldham: *Ibid.*, Vol. XIII, p. 215.

[8] W. T. Blanford: Pt. I, p. 305.

[9] W. H. Sykes: Trans. Geol. Soc., 2nd Ser., Vol. IV, p. 425.

[10] Dr. Leith: Jour. Bom. As. Soc., Vol. VI, p. 180.

[11] Trans. Geol. Soc., 2nd Ser., Vol. V, p. 549.

writers, it seems possible that the author quoted mistook the quasi-cubic crystals of apophyllite for the nearly cubic rhombohedrons which constitute one of the commoner forms of chabasite.

Hypostilbite constitutes one of the zeolites of the Deccan trap, but it appears to be known only from the specimens, from the Bombay presidency, examined by Dr. Haughton. In these the mineral occurred "in large, fibrous, transparent masses, radiated like natrolite or thomsonite, and filling globular cavities in green trap." Sp. gr. = 2·180. It yielded on analysis[1]—

Silica	52·80
Alumina	17·12
Lime	7·89
Magnesia	trace
Soda	2·35
Potash	·07
Water	18·52
	98·75

Stilbite is the commonest of the Deccan trap zeolitic minerals, next in abundance to it coming apophyllite, heulandite, and scolecite.[2] It occurs both in crystals, which are often of large size, and are very commonly associated with apophyllite, lining drusy cavities in the trap, and in radiated lamellar masses entirely filling such cavities. The finest crystals have been obtained from the Bhor and Thul ghâts. Great masses of the lamellar kind have been noticed at Bráhmanváda, in the south-east of Akola,[3] and between Jabalpur and Seoni. Other localities, for the mineral are the plain of Bijapur, Sholapur, Caranja, and Elephanta in Bombay harbour, the Narbada valley,[4] Poona, the Gawilgarh hills, and Saugor.

There is a fine series of crystallized specimens from the Ghâts in the museum, which were obtained, as well as those of apophyllite, heulandite, &c., by Dr. Blanford, during the construction of the Great Indian Peninsular Railway. The crystals include—

1st.—Salmon-coloured crystals, generally of considerable size—very commonly, for instance, an inch, and sometimes two inches, across (in the direction $\infty\breve{P}\infty$). They have the faces $\infty\breve{P}\infty.\infty\bar{P}\infty.P.$ (fig. 31), and are not uncommonly somewhat (but not highly) sheaf-like, from the aggregation of simple crystals into compound ones. They are generally (but not always) implanted by one end, and hence usually present only one pyramidal termination. Crystals of this kind are frequently thickly

[1] Jour. Roy. Geol. Soc. Ireland, 2nd Ser., Vol. I, p. 253.

[2] W. T. Blanford : Pt. I., p. 305.

[3] W. H. Sykes: Trans. Geol. Soc.,, 2nd Ser., Vol. IV, p. 425 ; Bombay Gazetteer, Vol. XVII, p. 16.

[4] T. Newbold : Jour. Roy. As. Soc., Vol. IX, p. 38.

grouped, occurring eitheralone or with apophyllite, which not uncommonly takes the form of minute crystals implanted on the surface of the stilbite. Quartz, &c., is also found in the same association, but not so frequently. In other cases the stilbite occurs in isolated crystals, being then very usually associated with large, thickly grouped, crystals of apophyllite.

2nd.—Highly sheaf-like forms, sometimes so much so that viewed on the face $\infty\breve{P}\infty$ they have the appearance of a fan, or in the comparatively rare cases where both ends of the crystal are free, of two fans with the points together: the crystals are commonly of considerable size, averaging, say, one half to one inch across. They are generally thickly grouped, but sometimes occur singly. They occur either alone, or associated with heulandite, apophyllite, scolecite, or with crystals of the third variety.

3rd.—Thin tabular crystals of comparatively small size (more commonly a quarter to an eighth of an inch across, sometimes much less); non-sheaf-like, or very slightly sheaf-like in form, and exhibiting the combinations $\infty\breve{P}\infty.\infty\bar{P}\infty.P.$ and $\infty\breve{P}\infty.\infty\bar{P}\infty.\infty P.P.$ (fig. 32). They occur alone, and with apophyllite, heulandite, scolecite, and perhaps other minerals. In one case small crystals of this kind were observed implanted on large ones of the first kind, showing that the former were of later formation. The crystals of the second and third varieties are white.

The crystals of the fourth kind, which are by far the least common, occur on the surfaces of cavities which are lined by minute crystals of quartz. No other zeolites are associated with them (except in one specimen which includes apophyllite). They are salmon-coloured; of considerable size, averaging, say, half an inch across; generally tabular and non-sheaf-like, or very slightly sheaf-like in form. Generally they present the faces $\infty\breve{P}\infty.\infty\bar{P}\infty.\infty P.P.$, but in some there is also a face replacing the edge between $\infty\breve{P}\infty$ and P. (fig. 33: the basal plane is present in some crystals, as in fig. 34, but it is almost microscopically small). The parallelism of the edges between this face and $\infty\breve{P}\infty.$ & P., respectively, shows that the furmula for the face in question is $m\breve{P}m.$ Striæ and irregularities on $\infty\breve{P}\infty.$ and P. prevent more than roughly approximate angular measurements. For $m\breve{P}m \wedge P.$ the value $152°\frac{1}{4}$ was obtained. A more reliable result, however, can be deduced from the observation that the plane angles formed by the edge between $m\breve{P}m.$ & $\infty P.$ with the edges between $m\breve{P}m.$ & $\infty\breve{P}\infty.$ and $m\breve{P}m.$ & P. (all of which edges are straight and sharply defined) are either right angles or extremely close approximations thereto. Assuming them to be actually right angles, the calculated value of $m\breve{P}m \wedge P.$ is 154° 35′, giving a value for m of 2·5098, or a close approximation to $\frac{5}{2}$. Taking m at $\frac{5}{2}$, the value of the angle $m\breve{P}m \wedge P.$ is 154° 41′, the plane angles formed by the

edge between m$\breve{P}$m. & ∞P. with the edges between m$\breve{P}$m. & $\infty\breve{P}\infty$. and m$\breve{P}$m. & P., respectively, being 90° 8′ and 89° 52′.

The values of the following angles therefore are—

$$\tfrac{5}{2}\,\breve{P}\,\tfrac{5}{2}.\ \wedge\ P. = 154° 41'.$$
$$\tfrac{5}{2}\,\breve{P}\,\tfrac{5}{2}.\ \wedge\ \infty\breve{P}\infty. = 145° 41'.$$

On one crystal there is also a face m$\breve{P}$m replacing the edge between $\frac{5}{2}\breve{P}\frac{5}{2}$ and $\infty\breve{P}\infty$. The value of m is much greater than $\frac{5}{2}$, but, owing to the position of the crystal in a cavity, it is impossible to get even a rough measurement of the angles between m$\breve{P}$m and the adjacent faces, without destroying the specimen.

Professor Heddle has noticed the occurrence of a face replacing the edge between $\infty\breve{P}\infty$. and P. on crystals of stilbite from Dumbartonshire, and from near Mount Nombi in Australia. He obtained the value 149°45′ to 150° for the angle m$\breve{P}$m. $\wedge\ \infty\breve{P}\infty$. in the Scotch specimens, and 152° 32′ to 153° in the Australian. These results, however, he considered little better than approximations, and he felt little doubt that the face was the same in the specimens from both localities.[1] The angles 149° 45′ and 153° respectively give a value for m of 2·9266 and 3·3497, the angle when m equals 3 being 150° 22′. The probability, therefore, would seem to be that the face noticed by Professor Heddle is different from that on the Indian specimens.

The total number of faces which, as far as the present writer has been able to ascertain, have hitherto been noticed on stilbite, are $\infty\breve{P}\infty$. $\infty\breve{P}\infty$. ∞P.P.0P., which are given in all mineralogical works; $\frac{3}{2}\breve{P}\infty$. noticed by Des Cloizeaux on crystals from Bergen hill (New Jersey);[2] m$\breve{P}$m (3$\breve{P}$3 ?) recorded by Heddle; $\frac{5}{2}\breve{P}\frac{5}{2}$ and m$\breve{P}$m (m having a high value) on crystals from the Western Ghâts.[3]

The following analyses have been made by Dr. Haughton :—

	Crystals, Narbada valley.[4]	Flat radiated crystals, Bombay presidency.[5]	"Rice grain" crystals, Bhor ghât.[6]
Silica	56·59	58·20	57·00
Alumina	15·35	15·60	17·10
Lime	5·88	8·07	7·95
Magnesia	·82	...	trace
Potash	·89	·92	} ·32
Soda	1·45	·49	}
Water	17·48	18·00	18·03
	98·46	101·28	100·40

[1] Mineralogical Magazine, Vol. IV, p. 44.
[2] Manuel de Minéralogie, Tome I, p. 416.
[3] F. R. Mallet : Records, G. S. I., Vol. XV, p. 153.
[4] Phil. Mag., 4th. Ser., Vol. XIII, p. 510.
[5] Jour. Roy. Geol. Soc. Ireland, 2nd Ser., Vol. I, p. 253.
[6] *Ibid.*, Vol. II, p. 113.

Stilbite is also found in the trap of the Rájmahál hills.[1] Crystals in the museum, from Karodih, are of small size, a quarter of an inch across and less, and show the faces $\infty\breve{P}\infty$. $\infty\bar{P}\infty$.P.

In the same collection there is a specimen of lamellar stilbite from the Andaman islands, doubtless obtained from the tertiary volcanic rocks.

Lamellar red stilbite has been observed, by Mr. Ball, forming veins in gneiss, south of the village of Manjuri, about 16 miles south-west from Daltonganj, in Palamow. The mineral is associated with pseudomorphous quartz, and the veins, which vary from ½ to 10 or 12 inches in width, lie, for the most part, parallel to the foliation of the gneiss, although they cut obliquely across it at several points.[2] Loose pieces of similar stilbite, which were in all probability derived from veins like those noticed by Mr. Ball, have been observed by the writer in the gneissose area of South Mirzapur.[3]

Syhadrite.—It has been pointed out by Dr. Blanford that the leek-green mineral, from the Bhor ghát trappean rocks, named syhedrite by Professor Shepard, is merely stilbite coloured by glauconite, and that the name should be syhadrite, from the Syhadri range.[4] Professor Shepard describes it as follows: "Hardness = 3·5. Gravity = 2·321. Massive; irregularly foliated in much contorted individuals, resembling common varieties of massive highly crystalline dolomite. Colour leek-green, that of the purest Indian heliotrope. Translucent on the edges only. Lustre vitreous. Cleavage in one direction very distinct. Brittle. Liable to alteration by exposure."[5] Mr. Tyler's analysis gave[6]—

Alumina	15·06
Ferrous oxide	2·71
Lime	6·45
Magnesia	2·46
Water	16·40
Silica (by difference)	56·92
	100·00

Epistilbite is said to occur in the Deccan trap,[7] Poona being given

[1] T. Oldham: Jour. As. Soc. Bengal, Vol. XXIII, p. 270; Memoirs, G. S. I., Vol. XIII, p. 215.

[2] Memoirs, G. S. I., Vol. XV, p. 36; Sci. Proc. Roy. Dublin Soc., Vol. II (1880), p. 121.

[3] Records, G. S. I., Vol. V., p. 22.

[4] Memoirs, G. S. I., Vol. VI, p. 141; Manual, Pt. I, p. 305.

[5] Am. Jour. Sci., 2nd Ser., Vol. XL, p. 110.

[6] *Ibid.*

[7] Pt. I, p. 305.

as a locality ; [1] but the writer is not acquainted with the original authority for the statement.

Heulandite is one of the commonest zeolites in the Deccan trap.[2] The finest specimens have been procured at the Bhor and Thul ghâts : large crystals are said to occur on the islands of Elephanta and Caranja, in Bombay Harbour,[3] and the mineral has also been noticed in Belgaum ; at Bráhmanvâda, in the south-east of Akola ; the plain of Bijapur ; the Sholapur district ; and the Narbada valley.[4]

There is a fine series of specimens in the museum, in which the mineral is associated with stilbite and apophyllite, and, less frequently, with scolecite, quartz, or calcite. The crystals are white, pale salmon-coloured, or reddish, and some of them are more than an inch long. They include the following combinations :—

$\infty\breve{P}\infty$. $2\breve{P}\infty$. — $2\breve{P}\infty$. 0P.
$\infty\breve{P}\infty$. $2\breve{P}\infty$. — $2\breve{P}\infty$. 0P. ∞P.
$\infty\breve{P}\infty$. $2\breve{P}\infty$. — $2\breve{P}\infty$. 0P. ∞P. — P.
$\infty\breve{P}\infty$. $2\breve{P}\infty$. — $2\breve{P}\infty$. 0P. ∞P. — P. $\breve{P}\infty$ (fig. 35).

Heulandite is also said to occur in the Rájmahál trap, at Karodih, Amrapara, and other places.[5]

III.—Margarophyllite Section.

(*a*) *Bisilicates.*

Talc.—As a constituent of talcose schist, and in the form of steatite, this mineral occurs somewhat frequently in the metamorphic and transition rocks of many parts of India (Pt. III, p. 439). It may perhaps be doubted, however, whether, in some instances, the rocks which have been described as talcose are not hydromica schists.

Glauconite.—Green earth occurs abundantly in the amygdaloidal portions of the Deccan trap, often filling the smaller cavities completely. The larger ones very frequently have a lining of the mineral, between the rock and the zeolite or agate which more or less completely occupies the cavity.[6] The green earth is also found in seams through the trap.

The only analysis that has been made is of the glauconite which forms

[1] Dana's System of Mineralogy, p. 444.
[2] *Vide* stilbite, page 123.
[3] R. D. Thomson : Madras Jour. Lit. and Sci., Vol. V, p. 162.
[4] T. Newbold : Jour. Roy. As. Soc., Vol. IX, p. 38.
[5] T. Oldham : Jour. As. Soc. Bengal, Vol. XXIII, p. 270.
[6] W. T. Blanford : Pt. I, pp. 302, 305.

the colouring material of hislopite,[1] a variety of calcite found in the trap rocks in question. This material yielded Dr. Haughton :—

		Oxygen ratio.
Silica	54·59	29·115 = 3
Alumina	4·74	
Ferrous oxide	22·84	9·513 = 1
Lime	·94	
Magnesia	4·90	
Water and loss	11·99	10·66 = 1
	100·00	

From which the formula $2\left(\frac{3RO}{AlO_3}\right).9SiO_2 + 6H_2O$ is deducible.[2]

(*b*) *Unisilicates.*

Serpentine is met with in some parts of the metamorphic rocks, as in Mánbhum and South Mirzapur, but perhaps the most extensive masses are those intrusions occurring in connection with younger rocks, like the triassic group of the Arakan Yoma, and the eocene (?) rocks of the same range, of the Andaman and Nicobar islands, and of Káshmir (Pt. III, p. 446).

Of the fibrous varieties *picrolite* (baltimorite) is associated with magnesite in the chalk hills of Salem. It occurs of a pale green and rich bluish-green colour, in thin veins not exceeding 6 inches wide.[3]

The serpentine of the Arakan range, in Burma, is intersected by veins of gold-coloured *chrysotile*,[4] and the same mineral, of a pale green colour, and highly satiny lustre, forms veins, ¼ or ½ inch thick, in the serpentine of the Bichi river, in South Mirzapur.[5]

Pholerite.—A mineral found near Simla by Colonel Ross, and called meerschaluminite by him, and Simlaite by Schrauf,[6] was subsequently shown to be pholerite by Messrs. Maskelyne and Flight.[7] According to their description, "it is massive, of a pale flesh-white, has a dull, even fracture, and adheres to the tongue. Patches and veins of a black mineral penetrated the mass in several places." An analysis of the flesh-

[1] *q. v.*

[2] $= \left.\begin{matrix}3RO \\ Al_2O_3\end{matrix}\right\} 3SiO_3 + 3HO$, as given by the author in the original (Phil. Mag., 4th Ser., Vol. XVII, p. 16; Jour. Roy. Dublin Soc., Vol. II (1858-59) p. 176.

[3] W. King and R. B. Foote : Memoirs, G. S. I., Vol. IV, p. 315.

[4] W. T. Blanford : Pt. II, p. 714.

[5] Records, G. S. I., Vol. V, p. 20.

[6] Verh. G. Reichs., 1870, p. 43.

[7] Jour. Chem. Soc., 2nd Ser., Vol. IX, p. 12.

white mineral, after the elimination of hygroscopic water, gave the following result :—

Silica	43·144
Alumina	41·073
Water	15·783
	100·000

The black infiltrated substance contained some manganese and cobalt, as also traces of organic matter, which were likewise present in the pholerite.

Mr. Brough Smyth mentions pholerite as amongst the minerals occurring in the South-East Wynaad.[1]

Kaolin has been reported from several parts of India, and in many cases the material so described has been directly formed by the disintegration of crystalline felspathic rocks, and is true kaolin in as far as can be judged from external characters only. But, with the exception given below, no analyses are available, showing how far the clays approach typical kaolin in composition. Some of them probably do so closely (Pt. III, p. 561).

The following analysis of kaolin, which is said to occur in large quantity in the Banda district, is by Mr. Otto Hebner[2] :—

Silica	44·47
Alumina	41·64
Oxide of iron	·34
Lime	·43
Magnesia	·18
Alkalis	·27
Combined water and organic matter	12·67
	100·00

Halloyite was found by Dr. Warth some years ago at the Kistul iron mine, in the Jaunsar district, North-Western Provinces. It occurs in nests through a mass of clay overlying an incrustation of limonite. "The mineral is of a peculiar horny appearance, and feels very fatty between the fingers." It is decomposed by hydrochloric acid, and, according to Dr. Warth's analysis, contains—

Silica	40·94
Alumina	39·77
Magnesia	2·57
Water	16·91
	100·19

Margarodite.—See muscovite.

[1] Report on Gold Mines of S.-E. Wynaad, p. 4.
[2] MSS.

Euphyllite.—An emerald green variety of this mineral has been found at Pipra, in South Rewah, where it occupies seams in the massive corundum noticed at page 48. Some of these are half an inch wide, or more, completely filled with euphyllite and black tourmaline. The foliæ of the micaceous mineral are generally small, but sometimes nearly half an inch across.[1] An analysis by Mr. Tween showed it to contain—

		Oxygen ratio.
Silica	43·53	13·95
Alumina	43·87	11·92
Oxide of chromium	·91	
Lime	1·45	1·00
Potash	7·80	
Water	4·60	2·35
	102·16	

If the water were regarded as basic, the above ratio would approximate to that required for the formula

$$3(RO.SiO_2)\ 4(Al_2O_3.SiO_2).$$

It is noticeable that the euphyllite of Pipra occurs in exactly the same association as that of Unionville, in Pennsylvania, namely, with corundum and tourmaline. It differs from that of other localities in containing chromium, and in the colour, which is probably due to the presence of that metal.

(*c*) *Subsilicates.*

Chlorite is of common occurrence, in many parts of the areas occupied by schistose rocks, as a constituent of chlorite schist, and is occasionally met with as a component of gneiss. In parts of Tenasserim chlorite is called the "mother of tin," as large scales of it are generally found where the ore is most abundant.[2]

In no instance, however, has the species of the chlorite been determined by analysis.

Chlorophæite is described as abundant in some parts of the Rájmahál trap.[3]

Appendix to Hydrous Silicates.

Chrome ochre (?). Mr. Calvert, writing of a part of the Parbatti valley below the village of Kasole, in Kulu, remarks that "in the quartzose rocks about here, and indeed for miles on, is much emerald-green oxide of chrome, which looks very beautiful, but is hard to detach."[4] Perhaps the substance is chrome ochre.

[1] F. R. Mallet: Records, G. S. I., Vol. V, p. 21.
[2] Select. Rec. Govt. Bengal, Vol. VI, p. 9.
[3] T. Oldham: Jour. As. Soc. Bengal, Vol. XXIII, p. 270.
[4] Kulu; its beauties, &c., p. 60.

3.—Phosphates, Arsenates, Nitrates.

A.—Phosphates, Arsenates.

I.—Anhydrous.

Apatite.—Crystals of dark bluish-green apatite have been obtained, together with beryl and chrysoberyl, from a coarse shorl-bearing vein granite, near the village of Ramidi, in Cuttack.[1] A few irregular pieces of sea-green apatite have been noticed in the granite of Northern Hazáribágh, previously alluded to under muscovite, but they are extremely rare.[2] Mr. Stœhr mentions having found in Singhbhum "a blue-black mineral of an elongated form, which Kengott considered to be apatite united with a carbonaceous substance."[3]

Earthy apatite, and *phosphatic nodules*.—In 1884 a band of massive, gray, earthy apatite was discovered by the Rev. Mr. Parsons and Dr. Warth at Mussooree. It is described as forming a band from 1 to 4 inches thick, and extending for more than a mile in length, just above the limestone, and at the base of the black chert bands. It is accompanied (apparently in the adjoining shale) by numerous gray phosphatic nodules, most of which are under an inch, or two, in diameter, although some are much larger. The following analyses have been made of the two varieties[4]:—

	Nodules.	Rock.
Phosphoric anhydride	34·70 = tricalcic phosphate 75·75.	30·16 = tricalcic phosphate 65·84.
Lime	46·42	39·21
Magnesia	·30	·55
Alumina Oxide of iron	3·50	5·58 2·63
Soluble silica	·20	·35
Insoluble siliceous matter Barium sulphate	9·57	16·06
Carbonaceous matter	·98	·92
Loss on heating to 100° C.	·32	·53
Carbonic acid, sulphuric anhydride, fluorine, undet., and loss	4·01	3·96
	100·00	100·00

[1] W. T. Blanford: Memoirs, G. S. I., Vol. I, p. 37.
[2] Records, G. S. I., Vol. VII, p. 43.
[3] *Ibid.*, Vol. III, p. 87.
[4] F. R. Mallet: *Ibid.*, Vol. XVIII, p. 126.

Both, however, appear to vary widely in composition, Dr. Waldie obtaining[1]—

	Nodules.	Rock.
Tribasic phosphate of lime	41·80	32·30
Phosphate of alumina	34·50	34·50
Lime	5·40	8·62
Magnesia and alkalis	2·10	3·00
SiO_2 and a very little SO_3	13·30	16·00
Loss on ignition	1·65	3·90
	98·75	98·32

while Mr. Hebner, in a sample of the nodules, found 87·05 per cent. of sand and clay, and only 3·98 per cent. of phosphoric anhydride.

Dr. Warth has recently found phosphatic nodules in the eocene strata of the Eastern Salt range. They occur in the shales above the coal, and are very numerous in the neighbourhood of the Dandot colliery, although not sufficiently so, as far as is yet known, to be of practical value.[2] His analysis shows—

Insoluble silica, &c.	4
Phosphorus pentoxide	30
Carbon dioxide	4
Sulphur trioxide	2
Chlorine	trace
Alumina	trace
Ferrous oxide	2
Magnesia	2
Balance—Lime, water, organic matter, and loss	56
	100

Coprolites have been found in some abundance, with fossil bones, in the Lameta beds at Pisdura hill, in East Berár.[3] They have also been obtained from the Kota-Maleri rocks of the Upper Godávari district, in Hyderabad.

Samples assayed by the writer gave—

	P_2O_5	=	$Ca_3P_2O_8$
Pisdura	24·75		54·04
Maleri	15·35		33·52

Pyromorphite.—Mr. M. Fryar reports having found thinly-scattered nodules of this mineral near the top of a small hill close to the mouth of the Onkarean, or Ankaren, stream, a tributary of the Thoungyeen river. The spot is about 80 miles east of Maulmain. Higher up the hill were two veins, each about 2 feet wide, of earthy phosphate and carbonate

[1] MSS.

[2] Records, G. S. I., Vol. XX, p. 50.

[3] S. Hislop, Q. J. G. S., Vol. XVI, p. 163; T. W. H. Hughes, Memoirs, G. S. I., Vol. XIII, p. 88.

of lead, from which he believed the nodules to have been derived.[1] The nodules have not been analysed quantitatively, but they contain so much arsenic that it is open to question whether they should not be referred to mimetite.

Mimetite, with pyrite, was found, apparently in some quantity, by Captain Foley, in limestone, in the Bo-thowng hills, about 90 miles north-north-east from Maulmain. It had been thrown aside as useless by the native miners.[2]

II.—Hydrous Phosphates and Arsenates.

Vivianite.—A stiff blue-gray clay, containing specks of blue earthy vivianite freely scattered through it, is of extensive occurrence in Nepal, where it is largely used as manure.[3] Samples of a similar clay were received last year from the Boisah Habee Tea Concern, in the Jorhaut district, Assam. It is evidently the same kind of vivianite that has been described, under the name of "mineral indigo," as having been found in the banks of the Diku river, above Názira, and in the Dhansiri river, in the same province.[4] It would seem, therefore, that the phosphatic clay in question is widely distributed. That from Nepal, Boisah Habee, and the Dhansiri, contained vegetable matter as well as phosphate.

Libethenite.—Small crystals of this mineral have been observed in the old refuse heaps at some of the Singhbhum copper mines.[5] Specimens in the museum show the combinations ∞P. P̆∞. and ∞P. P̆∞. P.

Chalcophyllite has been found under the same circumstances as the preceding mineral.[6]

Arseniate of copper (species not stated) is said to occur, with chalcopyrite and bornite, at Agur and Sahloo, in Kumaon.[7]

Lazulite.—Amongst some specimens from Káshmir, received from the Resident in 1883, was a piece of deep-blue lazulite, measuring about ¾ of an inch × ½ × ½. It is attached to white translucent quartz, and is said to have come from the Pádar district.

Turquoise.—Not known, with certainty, to occur in India, although it is said to have been found in Rájputána (Pt. III, p. 435), and in the territory to the eastward of the Tenasserim river.[8]

[1] Papers on the Geology of Burma, p. 457.
[2] Jour. As. Soc., Bengal, Vol. V, p. 280.
[3] H. B. Medlicott: Records, G. S. I., Vol. VIII, p. 100.
[4] Calcutta Jour. Nat. Hist., Vol. III, p. 153.
[5] M. E. Stœhr: Records, G. S. I., Vol. III, p. 89.
[6] *Ibid.*
[7] W. J. Henwood: Select. Rec. Govt. India, No. VIII, pp. 11, 22.
[8] J. W. Helfer: The Provinces of Ye, Tavoy, and Mergui, 2nd Report, p. 31.

The turquoise mines at Nishapur, in Khorassan, are beyond the limits of area that the present work refers to, but reference may be made here to a detailed account of them, by General A. H. Schindler, in the Records of the Geological Survey of India.[1]

Torbernite.—A few crystals of this mineral have been found, under the same circumstances as libethenite (*q.v.*), and in association with it.

B.—Nitrates.

Nitre.—This salt, which, after refining, is exported in very large quantity from India, occurs in, and as an efflorescence from, the soil, in and around villages. The conditions under which it is produced are very clearly described in the following account by Dr. W. J. Palmer, chemical examiner to the Government of India[2]:—

"A class or caste of men, called *soṛawallahs*, from the Hindu word *soṛa*, meaning nitre, make it the business of their lives to collect the raw material, manufacture, and sell the salt, either for local use, as a cooling agent in frigorific mixtures, or for exportation.

"The *soṛawallah* goes about the village, examining the small surface drains which issue from holes in the mud wall, usually found around native dwellings and their cow-houses; when he detects a faint white veil-like patch of crystalline formation, on or near the dark-coloured borders of these little drains, he knows that a considerable quantity of nitre exists, on or near the surface of all the surrounding earth; he accordingly proceeds to scrape off a very thin layer of the surface soil, which he carries away to his place of manufacture, as soon as his morning's collections are finished. On arriving there, the impregnated earth so collected is thrown into an earthen vessel containing either water, or water which has been poured off from previous supplies of similarly impregnated earth. When the water so used is pretty well saturated, it is poured into shallow pans of unglazed earthenware, in which it is then exposed to the combined influence of hot winds and the solar rays; these cause rapid evaporation, and the formation of crystals of nitrate of potash, which, after one or two more crystallizations, are ready for sale. The mother-liquor, on being further evaporated, yields a proportion of common salt, varying from one to seven or nine per cent. The *soṛawallah* makes fresh collections from precisely the same spots of ground, from week to week, year to year, and from generation to generation, after the manner of the eastern world; the production of nitre is constant so long as the place continues to be inhabited; it even continues to appear in large, though gradually decreasing quantities, for years after the village may have been deserted. The intervals at which fresh collections may be made from the same spot, vary in different localities, and in different seasons of the year, from one to seven, ten, or more days. Before suggesting any theory of the mode of formation of this nitre, it will be necessary to direct attention for a few moments to some points in the physical geography of the country, and in the economy of a native village, which differ widely from anything seen in Europe.

"Nitre is found in the plains of India, being most abundant in the parts most distant from the mountain ranges. The soil in these parts is composed of a very

[1] Vol. XVII, p. 132. [2] Jour. Chemical Soc., London, Vol. XXI (1868), p. 318.

uniform alluvium, or river-sand; for a depth of more than 200 feet, the uniformity of this is only broken by occasional thin layers of clay, indicating former river courses, and still more rarely by beds of rough, nodular, friable, stony masses, called *kunkur*,[1] each nodule of which is made up of granules of carbonate of lime so agglomerated that they enclose much of the surrounding sand, the proportion of carbonate of lime varying from fifteen to seventy per cent. These beds lie in a horizontal plane, at depths varying from one to twenty feet; they are from six inches to three or four feet thick; from one to three yards wide; and from one to several miles in length, with occasional interruptions. The yield of nitre is abundant only where these beds of *kunkur* exist in the soil, and where at the same time the natural water-level is from twenty to forty feet below the surface. In parts where the surface of the well-water is only a few feet below the level, there no nitre is gathered; it is probably carried away and diffused as soon as formed. Where, on the other hand, the water-level is more than twenty feet from the surface, all the watery parts of fluids thrown on the sandy surface are drawn to the surface and evaporated by the powerful sun, the solid particles remaining on the surface, to be gathered or washed away when the new rain falls.

"*Climate.*—For eight months in the year no rain falls in the nitre-producing parts of India; the soil is exposed to the continuous influence of a dry wind and a burning sun; during the remaining four months it is exposed to alternations of heavy tropical storms of rain with thunder and lightning, and a burning sun. The rain generally falls so rapidly that it rushes off the surface of the earth into neighbouring rivers; some, however, soaks for a varying distance into the soil, where it dissolves any soluble materials it may come in contact with, leaving it again on the surface as the water is drawn up and evaporated by the sun's influence. A greater quantity of nitre is collected in the rainy season than in any other, although it is evident that much more must at the same time be washed away.

"*The Village.*—The nitre-producing parts of India are more densely populated than England; the villages are large, and are made up for the most part of mud houses, surrounded by a mud wall, which generally encloses the dwellings of a whole family, including uncles and aunts and their families, as well as grand-parents and grand-children; every family will have at least one pair of plough-oxen. The only drains from these houses are the small surface ones before alluded to, and the only fluids which pass by these drains are urine and the small quantity of refuse water brought to the house for culinary or drinking purposes;[2] these drains open on to a small open plot of ground where the drainage diffuses itself, and is rapidly dried in the sun, the only other domestic refuse which finds its way to this spot being the daily contribution of wood-ashes, which results from cooking processes, any refuse food, or leaves used as plates by these people, being rapidly devoured by hungry eastern dogs, crows, or

[1] "These beds of "*kunkur*" are interesting as being the only stone-like formation seen for hundreds of miles along the left bank of the Ganges; as being the only available source of lime in the plains of India for ages; and also in their formation. In the extreme hot dry season, water, holding bicarbonate of lime in solution, appears to be drawn up from the depths of the earth; as this approaches the surface the whole of the water and part of the carbonic acid being driven off, granules of carbonate of lime are deposited, which coalescing imperfectly form these rough granular nodules."

[2] "All things requiring washing in a native house are carried to a neighbouring bank. All coarser refuse, as broken pots, &c., are thrown into a hole made when the earth was dug to build the house. Ordure does not find a place in this plot of ground, as a rule, for it is the custom for all members of an Indian household to retire once daily, in the early dawn, to the "bushes," or to a field, sheltered by a high growing crop, where they at once defecate and manure their land; at all other times in the day, urine is voided in the little open drain or gutter. Cowdung does not a find, a place there, it being invariably collected, dried in the sun, and used for cooking purposes."

their own cattle. It now appears that we have all the necessary elements for the continuous production of nitre ; there is urea in abundance, which, in the presence of carbonate of lime is probably converted into nitric acid and nitrate of lime by the influence of the severe thunder-storms in the rainy season, and possibly also by the active chemical influence of the sun's rays at other seasons. The nitrate of lime so formed is probably again decomposed by solution of carbonate of potash, giving rise to nitrate of potash, the solution of which is drawn to the surface of the earth in the ordinary course of evaporation, where it crystallizes and is gathered by the *sorawallah*. The small amount of chloride of sodium associated with the nitre is also probably derived from the urine.

> "The evidence in favour of this theory is—
> "*Firstly.*—That no other known source of nitre exists.
> "*Secondly.*—That nitre is found only in and near populous villages ; that it continues to be found on the same spot of ground so long as it is inhabited, and gradually ceases when a village is deserted.
> "*Thirdly.*—That the process is imitated successfully in some of our India jails, where the expense of removing urine to a distance has been avoided by setting apart a plot of ground to receive it; lime is then added to this, in case it does not exist in the soil naturally, and all the refuse wood-ashes are thrown in the same place. Nitre is formed, collected, and manufactured for sale to cover the cost of production."

Dr. Palmer's statement that nitre is only produced under the conditions above indicated, is possibly open to exception, the salt being sometimes, perhaps, formed under somewhat different, although more or less analogous, conditions. Thus, Dr. Helfer describes a great limestone cave on the Tenasserim river, which "is the habitation of thousands, and perhaps hundreds of thousands, of bats," the long-continued presence of which has led to the production of nitre on the floor of the cave.[1] In this case, however, the source of the potash is not so clear. Possibly the salt is really nitrocalcite.

The chief nitre-producing parts of India have been mentioned in the third part of the present work, (page 499,) and it will be sufficient here to say that Behár is by far the most important tract, while the North-West Provinces and Oude turn out a large amount. Smaller quantities are produced in various other parts of the country.

Soda-nitre.—Nitrate of sodium is mentioned[2] as sometimes forming one of the salts present in the efflorescence known as '*reh*,' so common in many tracts of the Indo-Gangetic plain in the Upper Provinces.[3] It is developed "where the soil has become loaded with organic nitrogenous matter," as in the case of nitre; and it may perhaps be inferred that the latter salt is generally more or less mixed with sodium nitrate, but the present writer is not aware of any analyses of the crude material. In some

[1] The provinces of Ye, Tavoy, and Mergui, p. 35.
[2] W. Center : Records, G. S. I., Vol. XIII, pp. 260, 261.
[3] W. T. Blanford, Pt. I, p. 413 ; V. Ball, *Ibid.*, Pt. III, p. 496.

instances the soda salt appears to form the most important constituent of such nitrous efflorescence. Samples of it, from Bellary and Hyderabad, were exhibited in the Madras Exhibition of 1857.[1]

Nitrocalcite.—Nitrate of calcium is considered by Dr. Palmer as an intermediate product in the natural formation of nitre, the nitrate of calcium first formed and the potassium carbonate of the wood-ashes undergoing double decomposition.[2] Nitrocalcite, according to this view, must be as widely diffused in India as nitre itself. It is sometimes present in *reh*, but under such circumstances, as well as when present in the more highly nitrous efflorescences utilised for nitre-making, it requires the presence of nitrogenous organic matter in the soil for its formation.[3]

In the vicinity of the Yenangyoung petroleum wells, in Upper Burma, which are sunk in clay and sand, "nitrate of lime is formed abundantly on the face of the rocks, and produces most beautiful groups of silky acicular crystals."[4]

4.—Borates.

Borax.—Although borax has been reported as occurring in Káthiawár[5] and Bikanir,[6] nothing is known about it with certainty, and the statements can scarcely be accepted without confirmation. All the borax which is exported from India is brought from the Trans-Himalayan region. The following *résumé* of the available information as to the localities where it is found, and the mode of its occurrence, is taken from an article signed "C. G. W. L." in Spon's Encyclopædia of the Industrial Arts[7] (1880). The author appears to have consulted some authorities not accessible to the present writer.[8]

"Borax (borate of soda) has been imported from Asia, from the earliest times, under one of its local names, *tinkál*. Before the utilisation of the Tuscan boracic acid, no other source than Asia was known, and even the now familiar word 'borax' is of Arabic origin. The modern discoveries of boracic compounds in less inaccessible parts of the world have done much to cripple the growth of the Asiatic product; but we still import considerable quantities from our Indian Empire. By many authorities,

[1] Jury Reports, p. 5.

[2] Page 136.

[3] W. Center: Records, G. S. I., Vol. XIII, pp. 254, 260, 261.

[4] T. Oldham: Appendix to Yule's Mission to the Court of Ava, p. 313. The occurrence of the salt may probably be ascribed to the labour employed at the wells.

[5] Select. Rec. Govt. Bombay, No. XVI, pp. 129, 135; Manual, Pt. III, p. 498.

[6] R. Irvine: Topography of Ajmere, p. 168.

[7] Division II, p. 533.

[8] The methods used for purifying the borax are also described, though omitted here as foreign to the scope of the present work.

the salt is stated as an Indian product; this is not the case, it is entirely of Trans-Himalayan origin. Stretching from Leh eastwards along the course of the Sutlej and the Brahmaputra, is a line of lakes, about a thousand miles in length, more or less explored. Many of these lakes are salt in a marked degree, have no outlet, lie at a high altitude, and are fed in a great measure by subterranean infiltration. Those situated in Ladák and Great Tibet, are the source of the so-called 'East Indian tincal.'

"The most westerly deposits are those found in the uninhabited lake-plain of Pugha, in the former country. It lies at an elevation of over 15,000 feet above the sea, on the Rulangchu, a small stream full of hot springs, joining the Indus on its left bank. The portion of the valley where the tincal is found may be roughly stated at 2 miles in length by $\frac{3}{4}$ mile in breadth, and, if not watered by, it is at least under the influence of, hot springs, whose temperatures in four places vary from 54° to 75° (130°—167° F.),[1] while the temperature of the stream fed by them reaches 13° (56° F.) in July. A sulphur mine exists on the banks of the stream, and numbers of coarse garnets are found in the neighbourhood. The deposit of impure borax, locally known as *sohaga*, has a thickness of several feet. It does not effloresce on the surface of the soil, as has sometimes been said; nevertheless a saline efflorescence, composed principally of sulphate and sesquicarbonate of soda, with more or less chloride of sodium, always indicate the existence of the subjacent beds of borax. The natives exhibit considerable skill in removing the valueless efflorescence and collecting the borax beneath, employing a kind of wooden spoon or spatula. The gathering of the mineral cannot be carried on at all times; on the contrary, each crop, as it may be termed, is dependent upon a catalytic action resulting from wet and subsequent evaporation, and having the effect of separating the borax from its impurities. The borax appears as a greasy substance, in a confused crystalline mass, of yellowish-green to dirty-white or gray colour, and is divided by the natives into three qualities. These, according to somewhat untrustworthy evidence, have about the following composition: No. 1. pure borax, from 68 to 85 per cent; chloride of sodium, 4 to 5 per cent.; sulphate of soda, traces to 6 per cent. No. 2. pure borax, 50 to 72 per cent.; chloride of sodium, 5 to 6 per cent.; sulphates of soda and lime, 10 to 20 per cent. This latter is in a powdery form. These two qualities are said to be generally mixed together, so as to yield an average of 70 to 72 per cent. of borax. The third quality is too impure for removal, and is left at the surface to cleanse itself by the natural process already mentioned. As artificial flooding has never been resorted to, the harvesting operation must be postponed till the occurrence of a natural downfall, which, at this elevation, usually takes the form of snow. The moisture sinks into the earth, taking up the impurities in its passage, as they are much more soluble than the borax. Under the influence of the sun, the soil dries up again, and the dissolved salts effloresce on the surface, while the borax, thus naturally (partially) purified, remains below. About ten or twelve days are allowed to lapse, after the downfall ceases, before the gathering of the crop is commenced. During the hot months of July and August, the production could probably be much increased or hastened by artificially flooding the ground. Frost causes a total suspension of operations for a great part of the year. The depth to which the borax-yielding earths extend has never been ascertained; but there is no doubt that they must exist in enormous, probably inexhaustible, quantities. The thickness of each crop of borax does not exceed about 2 or 3 inches, the effect of the catalytic action being limited to that depth; the lower portion of the deposit, which is still impure, is exposed to the surface by the removal of each crop. The quality of the borax earth is roughly judged by its hardness and weight. One man can collect a

[1] The hottest spring had a temperature of 178° F. in 1864 (Memoirs, G. S. I., Vol. V, page 163).

maund (about 80lb) in a day; it is filled into little woollen bags, holding about 25 to 30lb each."

* * * * * *

"Passing eastwards from the Pugha district, the next important source of borax is the lakes of Rudokh, where a superior quality, locally termed *chú tsalé* (water borax), is found. The interval between this point and the large lake of Tengri-Nur is not much known. The Pangong lake is reported saline; near Lumadodmo, are several small saline lakes, and in the vicinity are hot springs possessing medicinal properties; the Purang Cháka lake is saline, and great quantities of borax, locally termed *bul*, are found lying all around it, in beds varying from 2 to 10 feet in thickness, and of light, loose consistency; at Hissik Cháka, is a small saline lake; and, at Tong Cho Cháka, a much larger one. It is impossible to say whether any borax will be found in those lakes which are simply recorded as saline. The chain of saline lakes is terminated on the east by the Tengri-Nur, lying to the north of Lhasa (nearly 100 miles), and at an elevation of over 15,000 feet. The lake is of very considerable size, and is encompassed on all sides by rocky hills. Very few streams flow into the lake, whose waters are principally supplied by springs, and are subject to very little rise or fall. There is no outlet. The crude borax, or *tshoochal*, as it is called by the Tibetans (*teliya* in the plains), is deposited in the bed of the lake, never in dry ground nor in high situations, nor universally distributed over the lake bed even, but only on the borders of the lake, and in the shallowest depths. The bed of the lake is said to deepen gradually towards the centre, where great quantities of common salt are found, the depths being as completely monopolised by that substance as the shallows are by the borax. This latter is dug up in large crystalline masses, which are afterwards broken for convenience in transport. Here, as elsewhere, the supply seems inexhaustible, inasmuch as the holes from which the mineral is extracted soon become refilled. The lake is frozen as early as October, and remains so for a great portion of the year, during which operations are suspended. Borax is also found by the lake Bul Cho, a little to the north of the Tengri-Nur. It measures about 6 miles by 5 miles, and has no outlet; geysirs, or spouting hot springs, are found in the neighbourhood. The same saline deserts are found in Tartary, on the territory of the Mongols of Tsaidam. Holes 2 or 3 feet deep are dug in the arid, sterile soil, wherein the tincal collects and is periodically gathered. Southwards again from Lhasa is another lake, the Yamdok Cho or Palte, over 13,000 feet above sea-level, whence borax has been obtained from time immemorial."

Fig. 36 (after Levy) represents a crystal of borax from Tibet.[1]

5.—Tungstates, Molybdates.

Wolfram.—According to Captain Tremenheere, "The presence of tungstate of iron with stream tin in the Mergui province is very common; it has apparently an extensive distribution in some of the minor ranges near the sea, and becomes mixed with the tin in the beds of streams, after both are detached from their original sites. Nearly all the specimens of ore brought by Mr. Corbin last year from Malewan, on the Pakchan river, contain it in such abundance as would most likely interfere materially with the profitable working of the tin in many of those

[1] Schrauf's Atlas der Krystall-formen.

localities. It was not present with the stream tin procured last year from the Thebawlick, the Thengdon, and other rivers east of the town of Tenasserim." The stream tin obtained near Yahmon hill, about 20 miles south-south-east from Mergui, is particularly mentioned as containing wolfram, a large sample yielding on analysis 29·46 per cent. of tungstic acid.[1] Captain Tremenheere does not assign any reason for supposing that the wolfram and tinstone are not associated in one matrix. Dr. Mason also speaks of wolfram as a frequent associate of the Mergui stream tin;[2] but Dr. Oldham did not appear to think it so common, stating that it is intermixed with the tin ore, to a small extent, in a few of the localities noticed by him, but that in the majority it is absent.[3]

Far to the northward, wolfram has been observed at the Karen-ni village of To-lu-lu, about 40 miles east of Toungu. It occurs in association with tinstone, which forms irregular lodes at the junction of indurated slate and "lines of quartz" by which the slate is penetrated.[4] It may probably be inferred that wolfram is of frequent occurrence throughout the extent of the great belt of stanniferous country, noticed under cassiterite.

Wulfenite.—There is a specimen of this mineral, in the form of small wax-yellow crystals, on quartz, in the museum, which was obtained in the "Karen-ni country, Toung-ngu."

6.—Sulphates.

I.—Anhydrous.

Thenardite.—The water of the Sámbhar lake (and other salt lakes in Rájputána?) contains a considerable amount of sodium sulphate, which causes a good deal of trouble during the manufacture of salt, owing to its crystallizing out from the mother-liquor under certain conditions of concentration and temperature. It would appear that the sulphate formed is mostly the hydrous salt (mirabilite or Glauber's salt), but the anhydrous, or thenardite, also crystallizes out, the conditions necessary for its production being different from those required for the formation of Glauber's salt, and involving, apparently, a higher temperature of the sun-heated solution. Mr. Adam remarks that, attached to the crystals of common salt, are sometimes "numbers of anhydrous, opaque, prismatic

[1] Jour. As. Soc. Bengal, Vol. XI, p. 848.
[2] Natural Productions of Burma, p. 51.
[3] Select. Rec. Govt. India, No. X, p. 63.
[4] E. O'Riley: Jour. Roy. Geog. Soc., Vol. XXXII, p. 208.

crystals of sulphate of soda which have been formed at a high temperature."[1] A solution saturated at about 35° C. (95° F.), which is about the temperature of maximum solubility, deposits crystals of the anhydrous salt when heated some degrees higher,[2] or to a temperature easily attainable under the circumstances.

Thenardite is probably mixed with the Glauber's salt of *reh*, as a result of efflorescence.[3]

Barite is known to occur in the Kurnool, Jabalpur, Ajmere, and Simla districts, and in Rewah (Pt III, p. 473). Within the last year or two it has been discovered, by Dr. Warth, on the Mussooree cart-road, 2 miles from Rajpur; and in one bed of the Salt range cupriferous shales, noticed under chalcocite, radiated balls of the mineral in question occur in abundance.[4] It has also been found, in association with galena and quartz, on Maingay's island, in the Mergui archipelago.[5]

Celestite has been found sparingly in Lower Sind, and at Surdag in the Salt range (Pt. III, p. 474). One or two crystals, from the former locality, in the museum, are more than two inches long and nearly as broad, and show the faces $\breve{P}\infty$. $\infty\breve{P}$. 0P.

Anhydrite.—Massive white anhydrite, containing cleavable portions here and there, occurs, in association with gypsum, in the lower part of the Spiti valley, in the Punjab Himalayas. In the gypsum of the Salt range, large nodular cores of calcium sulphate, containing only 5 per cent. of water, and which are harder, of a higher specific gravity than, and somewhat different in colour from, the enclosing gypsum, have been noticed.[6]

Anglesite occursi n small quantity, associated with galena, in the Táraghar mine at Ajmere.[7] "Choice and beautiful specimens of carbonates and sulphates of lead from the lead mines at Ajmere" are mentioned as having been sent to the Asiatic Society in 1864.[8]

Glauberite was discovered, by Dr. Warth, in fissures of the salt at the Mayo mines in the Salt range.[9] The mineral occurs in crusts formed of brownish, and nearly colourless, transparent crystals, and also on cubes of rock-salt. The crystals have been examined by W. Schimper, who remarks that they are of exactly the same type as those from Westergeln,

[1] R. M. Adam, Inland Customs Administration Report, 1870-71, p. 126; R. Irvine, Topography of Ajmere, p. 168.

[2] Treatise on Chemistry, by Roscoe and Schorlemmer, Vol. II, p. 117.

[3] Page 142.

[4] A. Fleming, Jour. As. Soc. Bengal, Vol. XXII, p. 257; W. Theobald, *Ibid.*, Vol. XXIII, p. 661.

[5] M. Fryar: Indian Economist, Vol. IV, p. 44.

[6] A. B. Wynne: Memoirs, G. S. I., Vol. XIV, p. 74.

[7] R. Irvine: Topography of Ajmere, p. 166.

[8] J. C. Brooke: Jour. As. Soc. Bengal, Vol. XXXIII, p. 529.

[9] Memoirs, G. S. I., Vol. XIV, p. 80.

near Magdeburg. The predominant faces are 0P. and —P., while ∞P∞. and ∞P. are much smaller (fig. 37). The following new faces (also small) were observed on a few crystals (fig. 38) :—

$$-\tfrac{1}{2}P.$$
$$2P\infty.$$
$$\tfrac{2}{3}P\infty.$$

The angle 0P. ∧ $-\frac{1}{2}$ P. could only be approximately measured, as 0P. was much crumbled; the result obtained was 28° 46′. According to Zepharovich's values for the axes, it would be 27° 57′. On the other hand, the faces of the two new clinodomes were even and bright, and the following angles could be more accurately determined [1] :—

	Observed.	Calculated.
2 P∞. ∧ 2 P∞. =	55° 27′	55° 27′
$\frac{2}{3}$ P∞. ∧ 2 P∞. =	29° 56′	29° 53′

Sulphate of magnesium and potassium (?)—The potassium and magnesium salts from the Mayo mines, alluded to under sylvite,[2] consisted partly of sylvite and kieserite, partly of a colourless salt which was analysed by Mr. Tween with the following result [3] :—

Magnesium sulphate	58·02
Potassium sulphate	38·00
Potassium chloride	3·80
Water	·62
	100·44

Omitting the potassium chloride (doubtless intermixed sylvite) and water, this gives—

	I.	II.
Magnesium sulphate	60·43	57·97
Potassium sulphate	39·57	42·03
	100·00	100·00

—figures which do not accurately correspond to any simple ratio between the bases, although not very widely different from $(\frac{2}{3}Mg+\frac{1}{3}K_2)\,SO_4$, the calculated ratio for which is given in column II.

II.—Hydrous Sulphates.

Mirabilite.—The saline efflorescence known as *reh*,[4] so common in many parts of the Indo-Gangetic plain of the North-Western Provinces,

[1] Zeitschrift für Krystallographie und Mineralogie, Vol. I, p. 70. The angles given are those between the normals of the respective planes.

[2] Page 33.

[3] Memoirs, G. S. I., Vol. XIV, p. 80.

[4] W. T. Blanford, Pt. I, p. 413; V. Ball, *Ibid.*, Pt. III, pp. 495, 496.

the Punjab and Rájputána, consists mainly of sulphate, chloride, and carbonate of sodium. The relative proportions of the different salts, however, vary immensely. In some cases there is as much as 75, or even 97, per cent. of Glauber's salt to 25 or 3 of chloride, while other samples have yielded on analysis only ·4 per cent. of the former.[1] At Cawnpore the crude material is said to yield half its weight of sulphate in the ordinary course of manufacture.[2] Probably in most cases the Glauber's salt is mixed with a varying proportion of thenardite, owing to efflorescence. It may be suspected, indeed, that in the hot weather the latter is often the chief salt present.

A considerable amount of sodium sulphate is contained in the water of the Sámbhar lake (and other salt lakes of Rájputána ?), as previously noticed under thenardite.[3]

Gypsum is known to occur in numerous parts of India, and in rocks of various ages, including the palæozoic strata of the Salt range, on the one hand, and some alluvial deposits on the other, while in certain spots the mineral is being now deposited from hot springs. (Pt. III, p. 450.)

Within the last few years the mineral has been reported from some new localities.

About 7 miles north-north-west of Nagor, in Jodhpur, there is a bed of gypsum, probably not less than 5 feet thick, in the alluvium. Mr. Oldham believes it to have been formed in a salt lake. The same substance is said to occur also at Dakoria and Bhaddana, but whether it is continuous between those places has not been determined.[4] The Nagor gypsum is dug to some extent, and is used in the Jaipur School of Art, but only for coarser purposes, as the plaster made from it is inferior to that imported from England.

Gypsum is described as occurring in some abundance near Mussooree in the lower part of the limestone.[5] "Endless quantities of excellent quality" are said to exist at Khátan, in North-Eastern Baluchistán. In the crevices of the oil-bearing rocks there, crystals of selenite are found, often containing "small globules of both solid and liquid petroleum."[6]

Gypsum has also been reported from more than one locality in Afghánistán, where it occurs in jurassic and tertiary rocks.[7]

Kieserite was discovered in the Mayo salt mines, by Dr. Warth,

[1] Select. Rec. Govt. India, No. XLII, pp. 81, 82.
[2] Trans. Med. Phys. Soc. Calcutta, Vol. V, p. 438.
[3] Page 140.
[4] MSS. Report, 1885-86.
[5] H. Warth: Indian Forester, Vol. X, p. 115.
[6] R. A. Townsend: Records, G. S. I., Vol. XIX, pp. 208, 210.
[7] C. L. Griesbach: Records, G. S. I., Vol. XIX, pp. 251, 252, 255, 258.

under the circumstances noticed in connection with sylvite.[1] The mineral, which was mixed with sylvite and rock-salt, occurred in grains with a maximum diameter of about half an inch. It was colourless, and possessed the same hardness and cleavage as the Hallstadt kieserite. Parts of it seemed to be compact. It was found to contain 12·99 per cent. of water, the calculated proportion being 13·04. The kieserite changed into epsomite, in a moist atmosphere, so that specimens in which it predominated became quite disintegrated at the surface, and presented a constantly deciduous coating. Mr. Tween's analysis, already quoted, gave magnesium sulphate 7·78, water 2·10, which is equivalent to kieserite 8·95, water 0·93, the latter being perhaps due to the alteration just noticed.

Besides being mixed with the sylvite, kieserite also prevailed through 7 feet of the *kallar*, or impure rock-salt, band beneath.[2]

Blœdite.—The discovery of this mineral is also due to Dr. Warth. It was found in fissures of the rock-salt in the Varcha (or Wurcha) mine, in the Salt range, about 30 miles west-north-west from Shahpur. The mineral occurs in colourless, more or less perfectly transparent crystals, with smooth faces and sharp edges; some are of very large size, as much as 4 inches $\times 3 \times 1\frac{1}{2}$ or 2. They have been described by W. Schimper,[3] who remarks that they are of exactly the same type as those from Stassfurt previously described by G. Vom Rath, and represented his figure 21.[4] The faces observed on the Varcha crystals (fig. 39) are as follow :—

0P.	Predominant.
$\breve{P}\infty$	
−P.	
∞P.	
$\infty\breve{P}2$.	
$\infty\breve{P}\infty$.	
$\infty\breve{P}\infty$.	
$\infty\breve{P}3$.	
$\infty\breve{P}2$.	
$+2\breve{P}\infty$.	
+P.	
$+2\breve{P}2$	
$-2\breve{P}2$	

All the above faces were observed on the Stassfurt mineral, with the same relative degree of development. The angles of the Varcha crystals

[1] Page 33.
[2] Memoirs, G. S. I., Vol. XIV, p. 80.
[3] Zeitschrift für Krystallographie und Mineralogie, Vol. I, p. 70.
[4] Poggendorff's Annalen, 1871, p. 586; and Plate VII, Fig. 2

mostly coincided, to within one minute, with the observations of Groth and Hintze on those from Stassfurt. In addition two new forms were observed, though only subordinate,—

		Measured.	Calculated.
1st.	$\infty P3$.		
	$\infty P3 . \wedge \infty P2 . =$	6° 7′	6° 47′
	$\infty P3 . \wedge \infty P\infty . =$	13° 49′ to 14° 8′	14° 7′
2nd.	$+P4$.		
	$+P4 . \wedge P\infty . =$	6° 23′	6° 6′

Mr. Drew describes "a layer of a hard, colourless, translucent substance, which seems to be a mixture of sulphate of magnesia with a compound of soda," over an area of a few square yards here and there, on the plain bordering the salt lake of Rupshu.[1] Is this blœdite (?), a substance which is known to exist at the salt lakes near Astrakan.

Epsomite.—Magnesium sulphate is frequently present in *reh*.[2] In the western part of the Chánda district, beneath the recent conglomerates and ossiferous gravels, there is a brownish-yellow clayey sandstone, containing a certain amount of saline matter, which effloresces at the outcrop. Two samples prepared by lixiviation and evaporation afforded on an analysis[3]—

Sodium chloride	82·89	87·58
Magnesium sulphate	16·02	11·86
Clay and organic matter	1·60	1·40
	100·51	100·84

Epsomite exists in considerable quantity in the Phurwalla salt mine, in the Salt range, impregnating, and effloresceing from, a bed of marl at least 7 feet thick. It is also found, although in smaller quantity, in the other mines, occurring in the thin seams of marl which sometimes separate the good salt layers from each other.[4]

The mineral occurs plentifully in some parts of the Lower Spiti valley, in the Punjab Himalayas, as an efflorescence on pyritous slate;[5] and a similar efflorescence has been noticed on alluvial clay in the Nicobars.[6]

Melanterite.—Ferrous sulphate is a not uncommon product of the

[1] Jummoo and Kashmir Territories, p. 300.
[2] *Vide* page 142; W. Center: Records, G. S. I., Vol. XIII, p. 261.
[3] T. Oldham: Central Provinces Gazetteer, p. xlv.
[4] H. Warth: Inland Customs Administration Report, 1869-70, Appendix H, pp. 155, 160.
[5] Memoirs, G. S. I., Vol. V, p. 160.
[6] H. Rink: Select. Rec. Govt. India, No. LXXVII, p. 136.

decomposition of pyrites, occurring generally as an efflorescence on the outcrop of rocks containing a considerable quantity of the latter mineral. Very often it is mixed with ferric sulphate. It is found at the Khetri copper mines, in Shekawati;[1] in the hills of the Kakur district, in Afghánistán;[2] in the Rámganga and Garjia valleys, in Kumaon;[3] on the outcrop of the Bijigarh (Vindhyan) shales of the Kaimur table-land;[4] in the valley of the Langyen, a stream which flows into the Diyun branch of the Kopili, in Central Assam; and at the headwaters of the Attaran river, in Tenasserim.[5] The mineral is described as occurring in considerable quantity at nearly all the above localities, and at the Khetri mines, the Kakur district, and the Kaimur plateau, it is collected and sent into the market, after purification.

Goslarite.—An efflorescence of zinc sulphate is said to occur "generally through the volcanic region" of the Ghorband valley, in Afghánistán.[6]

The present writer has been informed by Mr. Griesbach that there are no recent volcanic rocks in the Ghorband valley, and the statement respecting the occurrence of zinc sulphate requires confirmation.

Chalcanthite.—Sulphate of copper exists in considerable abundance in the copper mines of Khetri, in Shekawati,[7] being there, as elsewhere, the result of the oxidation of sulphuretted ores. It has also been noticed in the Seestungee mine, in Northern Afghánistán,[8] and in that of Mangphu, in the Teesta valley, Darjiling district.[9]

Alunogen occurs in the old 'alum shale' mines at Mharr, in Kachh, forming seams, some an inch and a half, or perhaps more, in width, which are composed of silky fibres perpendicular to the walls of the seam.[10] A fine specimen of the mineral, occurring in similar seams through a dark slate, and associated with melanterite, was recently presented to the museum by Dr. Warth. It was obtained from a drift in the (nummulitic) coal mine near Pid, in the Salt range. The aluminous salt of the 'alum shales' which have been worked in several parts of India is probably in most cases alunogen, as, in the manufacture of alum, nitre is added to supply the potassic element of the compound (Pt. III, p. 431).

[1] J. C. Brooke: Jour. As. Soc. Bengal, Vol. XXXIII, p. 529.
[2] T. Hutton: Calcutta Jour. Nat. Hist., Vol. VI, p. 597.
[3] J. D. Herbert: Asiatic Researches, Vol. XVIII, Pt. I, p. 229.
[4] F. R. Mallet: Memoirs, G. S. I., Vol. VII, p. 121.
[5] E. Riley: Jour. Indian Archipelago, Vol. III, p. 395.
[6] P. B. Lord: Jour. As. Soc. Bengal, Vol. VII, p. 536.
[7] J. C. Brooke: *Ibid.*, Vol. XXXIII, p. 525.
[8] Drummond: *Ibid.*, Vol. X, p. 77.
[9] Memoirs, G. S. I., Vol. XI, p. 8.
[10] A. B. Wynne: Memoirs, G. S. I., Vol. IX, p. 87.

The sulphate of aluminium obtained in Nepal and Kumaon, and known as *salajit* (Pt. III., p. 435) and which is described as being soluble in water, is perhaps alunogen. It must, however, be a different salt, if the composition, as given by Mr. Stevenson and Dr. Campbell (95 and 66 per cent. of (anhydrous ?) aluminium sulphate) be correct.

Kalinite occurs as an aggregate of minute crystals, forming veins up to 3 inches in thickness, in the native sulphur mine at Puga, in Ladákh.[1]

'Alum shales' occur in several parts of India, but, as remarked under the preceding mineral, the salt contained in them is probably, in most cases, alunogen.

7.—Carbonates.

I.—Anhydrous.

Calcite—*Crystallized.*—No very remarkable crystallized forms of calcite appear to have been met with in India. The most noticeable crystals, perhaps, are those which occur in the Deccan trap. They are especially common in the interior of quartzose geodes,[2] but also occur in association with zeolitic minerals. The crystals hitherto noticed have been rhombohedrons (R. & $-\frac{1}{2}$R.) and scalenohedrons (dog-tooth spar).

Cleavable.—In some cases the quartzose geodes just mentioned are completely filled with calcite, and, in others, cavities in the trap are entirely occupied by the latter mineral in a cleavable form. It occurs of various tints : colourless and transparent, (although the writer is not aware that any is ever found sufficiently pellucid for optical purposes) ; pale yellow; and dark brown, or black.[2]

A vein of "rhombohedral" (cleavable ?) calcspar, traversing limestone and not less than 20 yards broad, has been noticed in the Belgaum district.[3] Similar veins, from a few inches, to a foot or two, in width, have been found in the gneissose rocks south of Rániganj, and worked on a rather considerable scale for lime.[4]

Hislopite.—This name was given, by Dr. Haughton, to a grass-green variety of cleavable calcite, owing its colour to enclosed glauconite, and which is found in the Deccan trap.

[1] F. R. Mallet : Memoirs, G. S. I., Vol. V, p. 163.
[2] W. H. Sykes : Trans. Geol. Soc., 2nd Ser., Vol. IV, p. 425.
[3] A. Aytoun : Trans. Bom. Geog. Soc., Vol. XI, p. 44.
[4] T. W. H. Hughes : Records, G. S. I., Vol. VII, p. 124.

When the mineral is treated with dilute hydrochloric acid, the calcite is dissolved, and a skeleton of glauconite remains. The author quoted found the specific gravity = 2·645, and obtained the following result on analysis :—

Calcium carbonate	80·79
Magnesium carbonate	trace
Glauconite	16·63
Alumina	·73
	98·15

The composition of the glauconite has been previously given.[1]

The specimen of hislopite examined by Dr. Haughton was from Takli (near Nágpur ?).[2] Colonel Sykes noticed a mass of the mineral, 2 feet in diameter, at Gorgaon, north of Aklapur, in the Ahmadnagar district.[3]

Fibrous calcite forms seams some inches in width, in the intertrappean beds of the Deccan trap. The fibres run perpendicularly to the walls of the seam, and are often so fine and silky as to constitute true satin spar. There are specimens in the museum from Dodchi, in the Narbada valley, and from the Wardha district.

"Fibrous limestone" is described, by Dr. McClelland, as occurring, amongst the transition rocks, at the north-eastern extremity of the Oudepore mountains, and in the valley of Barabice, in Kumaon. "The strata are usually thin, and the whole bed seldom occupies more than a few feet in thickness."[4]

Calc-tufa.—Immense masses of this substance are met with in many parts of the country, having been deposited by dripping or running water holding calcium bicarbonate in solution. The largest accumulations are formed on or below limestone or dolomite, but considerable masses are also found which have derived their material from rocks containing but a small proportion of lime, which has been gradually leached out in the course of time. As cases in point, Dr. Warth states that "beautiful accumulations of calcareous tufa are seen at Sahansra Dhára, at the Mossy falls, Bhatta falls, Kempti falls, and other waterfalls which are often visited from Mussooree," the material having been derived from dolomitic limestone.[5] Very large masses occur along the base of the dolomite hills in the West-

[1] Page 127.

[2] Phil. Mag., 4th Ser., Vol. XVII, p. 16; Vol. XXIII, p. 50; Jour. Roy. Dublin Soc. Vol. II (1858-59), p. 176.

[3] Trans. Geol. Soc., 2nd Ser., Vol. IV, p. 425.

[4] Geology of Kumaon, p. 125.

[5] Indian Forester, Vol. X, p. 115.

ern Duárs.[1] Although deriving their material from dolomite, containing nearly 40 per cent. of magnesium carbonate,[2] they are formed of nearly pure carbonate of calcium, as is shown by the following analyses by Mr. Tween :—

	Porous tufa.	Crystalline tufa.
Calcium carbonate	98·10	98·50
Magnesium carbonate	1·30	1·50
Oxide of iron, alumina, and insoluble . . .	·80	·06
	100·20	100·06

The water which deposits such masses as those at Mussooree and in the Duárs, is so highly charged with lime as to form petrifying springs and rivulets; the beds of the streams, and everything in them—stones, leaves, twigs, &c.—are all encrusted with tufa.[3]

As an instance of tufa formed where limestone is absent, the masses which occur about many of the waterfalls over the Rewah and Kaimur escarpments may be mentioned. Although some of the streams traverse the Bhánrer limestone and calcareous shales, others flow over sandstone only.[4]

Stalactite differs from calc-tufa merely in its outward form, the latter being deposited by water running or trickling over the surface; the former by water dropping, with a free fall.

Stalactites and stalagmite are abundant in the limestone caves of Tenasserim,[5] and in the similar caves of Billa Surgam, in Kurnool.[6]

Peastone, "in globular concretions, from the size of a grain of mustard seed to that of a pea," is found in Tibet, and used there as a medicine.[7]

"*Agaric mineral,* or rock-milk, is very abundant in hollows in the soil, and in fissures in rocks of Ajmere and to the south-west. It is generally composed of fine, white, dusty particles of pure carbonate of lime."[8]

Limestone.—A description of the very numerous limestones of India scarcely falls within the scope of the present work, and it is the less necessary as the subject has already been treated, in considerable detail, by Mr. Ball (Pt. III, p. 455). It may be remarked here, however, that

[1] F. R. Mallet: Memoirs, G. S. I., Vol. XI, p. 87.
[2] Page 151.
[3] *Op. cit.*
[4] Memoirs, G. S. I., Vol. VII, p. 115.
[5] E. Riley, Jour. Indian Archipelago, Vol. III, pp. 397, 743; F. Mason, Natural Productions of Burma, p. 29.
[6] R. B. Foote: Records, G. S. I., Vol. XVIII, p. 227.
[7] Stevenson: Jour. As. Soc. Bengal, Vol. IV, p. 520.
[8] R. Irvine: Topography of Ajmere, p. 167.

some of the rocks in question are of extreme purity, in illustration of which the following analyses are quoted :—

	I.	II.	III.	IV.
Calcium carbonate . . .	99·03	98·790	98·60	99·64
Magnesium carbonate . .	·26	·684	·55	...
Alumina	...	·105	·30	·03
Oxide of iron	·50			
Oxide of manganese . . .	·20	...	...	...
Insoluble	...	·005	·55	·33
	99·99	99·584	100·00	100·00

I.—Carboniferous limestone ; Thaungyin valley, Tenasserim.[1]

II.—Cretaceous (?) limestone; south-east of Tsetama, Ramri island, Arakan.[2]

III.—Nummulitic limestone; Chela, at debouchure of Bogapáni, Khási hills.[3]

IV.—*Ibid.*, Rohri, Sind.[3]

Chalk.—The occurrence, in Afghán Turkistán, of true chalk with flints, similar to that of England, has been recently recorded by Mr. Griesbach. Together with shell limestone, it constitutes the highest beds of the upper cretaceous rocks, forming about one third of the total thickness of the group.[4]

Kankar.—This concretionary form of more or less impure calcium carbonate, which is found in the alluvial deposits of India, and especially in the older ones, ought not to be omitted in a description of the mineral under discussion. It has, however, been already described in the preceding parts of this work (Pt. I, p. 381; Pt. III, p. 471).

Coral.—The same remark applies to the coral which is found on so many parts of the Indian coast, and forming islands in the Indian seas (Pt. I, p. 376; Pt. II, p. 735; Pt. III, p. 470).

Dolomite.—Hopper-shaped pseudomorphous casts, after salt crystals, have been observed in dolomitic layers occurring in the gypsum of the Salt range.[5] No other very remarkable crystallized forms of this mineral have been recorded, but as a rock it occurs abundantly in strata of various ages.

Thus, Mr. Foote has described the occurrence of great masses of dolomite, occurring in beds of great thickness, in the metamorphic rocks near Goa.[6] Dolomite has also been noticed in similar rocks at Khorari, near

[1] R. Romanis: Report on Minerals of Tenasserim, p. 4.
[2] T. Blyth, MSS.
[3] Hira Lal, MSS.
[4] Records, G. S. I., Vol. XIX, pp. 253, 254.
[5] A. B. Wynne: Memoirs, G. S. I., Vol. XIV, p. 74.
[6] Memoirs, G. S. I., Vol. XII, p. 55.

Nagpur [1] (which is perhaps the same as Korhádi, where "coarsely crystalline saccharoid dolomite" occurs [2]); at Dhelwa, north of Gáwan, in Házaribágh; [3] and in the southern part of the Mirzapur District.[4]

The following analyses have been made:—

	I.	II.	III.	IV.	V.
Calcium carbonate . .	56·4	61·80	54·35	53·85	64·68
Magnesium carbonate . .	34·8	38·20	42·07	45·78	34·14
Ferrous carbonate . .	...	...	...	·34	·58
Oxide of iron . . .	3·6	...	·68	...	...
Water & organic matter .	4·0	...	...	...	...
Insoluble	2·2	...	2·90	1·00	·76
	101·0	100·00	100·00	100·97	100·16

I.—Near Goa; light-gray saccharoid. With the oxide of iron is also included a little alumina and oxide of manganese.

II.—Korhádi; as above = $(\frac{4}{7}Ca + \frac{3}{7}Mg)\ CO_3$

III.—Dhelwa; light gray crystalline. Corresponds nearly to $(\frac{1}{2}Ca + \frac{1}{2}Mg)\ CO_3$.

IV.—Bichi river, South Mirzapur; white crystalline. Corresponds to $(\frac{1}{2}Ca + \frac{1}{2}Mg)\ CO_3$.

V.—North of Parárwa, South Mirzapur; white, rather coarsely crystalline. Corresponds to $(\frac{3}{5}Ca + \frac{2}{5}Mg)\ CO_3$.

Dolomite is especially abundant in the transition rocks of some tracts. It is common in the Jabalpur District, as at the celebrated marble rocks; [5] is largely quarried, for marble, near Kankraoli, in Meywar; [6] forms a magnificent band of rock in the Western Duárs; [7] and, together with talcose schist, &c., constitutes the gangue at several of the copper mines in Kumaon and Garhwál.[8]

The following analyses may be quoted:—

	I.	II.	III.
Calcium carbonate	55·48	59·7	60·5
Magnesium carbonate	43·55	37·8	38·7
Ferrous carbonate	·36	...	...
Oxide of iron and alumina	...	1·0	·3
Insoluble	·61	·8	
	100·00	99·3	99·5

[1] H. W. Voysey: Asiatic Researches, Vol. XVIII, Pt. I, pp. 127, 201.
[2] S. Haughton: Phil. Mag., 4th Ser., Vol. XVII, p. 16.
[3] F. R. Mallet: Records, G. S. I., Vol. VII, p. 34.
[4] *Ibid.*, Vol. V, p. 19; Vol. VI, p. 42.
[5] F. R. Mallet: Records, G. S. I., Vol. XVI, p. 113.
[6] J. Hardie: Asiatic Researches, Vol. XVIII, Pt. II, p. 78.
[7] F. R. Mallet: Memoirs, G. S. I., Vol. XI, pp. 34, 83.
[8] E. T. Atkinson: Economic Mineralogy of Hill Tracts, pp. 21, 22, 23, 25, 26, 27.

I.—Marble rocks; white saccharine. Corresponds to ($\frac{1}{2}$Ca + $\frac{1}{2}$Mg) CO_3. "A block was sent to the late Paris Exhibition, and pronounced to be equal to Italian marble for statuary purposes."[1]

II.—Light gray saccharoid. Titi river, Western Duárs.[2]

III.—White, almost crypto-crystalline. Titi river. The excess of lime over the normal ratio, in II and III, is due to crystals of calcite, which line little drusy cavities in the dolomite.

The limestone, of undetermined age, at Naini Tal and Mussooree,[3] is mainly dolomitic, as is shown, with reference to the latter place, by the analyses quoted :—

	I.	II.	III.	IV.
Calcium carbonate	58·9	50·4	48·8	56·7
Magnesium carbonate	33·2	47·1	48·2	33·3
Insoluble	4·7	·5	·3	6·1
Water, bituminous matter, and loss	3·2	2·0	2·7	3·9
	100·0	100·0	100·0	100·0

I.—Fine gray. Top of Camel's-back.

II.—Dark crumbling. Near Jharipáni.

III.—White crystallized. *Ibid.*

IV.—A mixture of fifty specimens of limestone and dolomite, from all over the Mussooree range.

The Tirhowan (Lower Vindhyan) limestone[4] is also dolomitic, at least in part, as shown by the figures below[5] :—

Calcium carbonate	52·86
Magnesium carbonate	37·57
Oxide of iron and alumina	2·23
Water and organic matter	1·03
Insoluble	6·31
	100·00

The examples quoted are merely given as illustrations of the occurrence of dolomite, not as anything approaching a complete list of the localities where it is found.

Magnesite forms innumerable veins, in talcose, chloritic, and hornblendic rocks, over a large area near Salem, in the Madras presidency. Associated with it are baltimorite, chalcedony, jasper, chromite, and talc (Pt. III, p. 438).

[1] Catalogue of Contributions from India to the London Exhibition of 1862, p. 17.
[2] Memoirs, G. S. I., Vol. XI, p. 83.
[3] H. Warth : Indian Forester, Vol. X, pp. 114, 118.
[4] H. B. Medlicott : Memoirs, G. S. I., Vol. II, p. 13.
[5] A. Tween, MSS.

The following analyses of the mineral have been made :—

	I.[1]	II.[2]
Carbonic acid	51·66	51·83
Magnesia	48·34	47·89
Lime	...	·28
Oxide of iron and alumina	traces	...
Silica	·30	...
Water	·80	...
	101·10	100·00

Veins of magnesite are met with in the serpentine of the Arakan range, in Burma,[3] and, under exactly similar circumstances, in Manipur.[4]

Impure magnesite has recently been discovered, by Captain F. Pogson, in the dolomitic limestones of the Happy valley, near Mussooree. Dr. Warth's analysis afforded [5] :—

Magnesium carbonate	69·1
Calcium carbonate	13·5
Silica, alumina, &c.	13·2
Water, bituminous matter, and loss	4·2
	100·00

Siderite.—Spathic iron has been noticed in association with the stibnite of Shigri, in Lahol.[6] With limonite, it forms a vein, 4 feet thick, at Choocoota, in Kumaon.[7] It is said to occur in layers, and irregularly dispersed, through dolomitic limestone, in the Bundi territory, Rájputána, in association with yellow and brown ochre.[8]

Clay-ironstone is abundant in the 'ironstone shales' of the Rániganj coal-field, and is found, in the same strata, in the other fields of the Damuda valley, although not so plentifully. The same ore has also been met with in some other parts of India, and in rocks of a different age, as in the tertiary coal-fields of Upper Assam (Pt. III, pp. 336, 369, 376, 412).

Smithsonite.—Certain specimens of fawn-coloured, ferruginous carbonate of zinc, which there is every reason to believe came from the old Baswapur-Gazoopilly lead mines, in Kurnool, have been alluded to under 'Newboldite.' [9] In outward characters, and in the associated minerals—

[1] J. Prinsep : Jour. As. Soc. Bengal, Vol. IV, p. 510.
[2] Stromeyer : Archiv. für die gesammte Naturlehre, Vol. IV, p. 432.
[3] W. T. Blanford : Pt. II, p. 714.
[4] R. D. Oldham : Memoirs, G. S. I., Vol. XIX, p. 225.
[5] Indian Forester, Vol. X, pp. 115, 118.
[6] Page 12.
[7] W. J. Henwood : Select. Rec. Govt. India, No. VIII, p. 18.
[8] Rájputána Gazetteer, Vol. I, pp. 206, 207, 208.
[9] Page 18 ; see also Records, G. S. I., Vol. XIV, pp. 196, 305.

barite, hornstone, "a dull-green crystallized mineral," and specks of galena and pyrites—they agree in almost every respect with, and do not disagree in any marked way from, the ore described as "carbonate of iron, lime, and cerium" by Mr. Piddington,[1] and also noticed by Captain Newbold,[2] by whom the specimens, which were analysed by the former author, were obtained *in situ* from the mines just mentioned. In a qualitative examination, the present writer obtained iron, zinc, lime, and magnesia, and, in his opinion, there is little doubt that Mr. Piddington mistook zinc for cerium, an error which seems to have also occurred in his examination of 'nepaulite.'[3]

Zinc is said to have been formerly obtained, in considerable quantity, at Jawar, south of Oodeypore, in Rájputána, and there is some reason to suppose that the ore was the carbonate.[4]

Aragonite is mentioned by Captain Newbold as one of the minerals occurring in the Deccan trap.[5] Aragonite, mixed with calcite, has been described by Mr. Fedden as forming a vein, 30 inches wide, or less, in the trap, about 15 miles north-west of Dhoráji, in Káthiawár.[6] In the Lower Spiti valley, in the Punjab Himalayas, the *débris* from the slopes above, and the recent or sub-recent conglomerates formed by the river, are in several places cemented by aragonite. The mineral is pure white, and is usually radiated-fibrous; rarely in small radiating crystals. Sometimes it lines cavities, in fibrous mammillary coats one or two inches thick. Considerable masses of the mineral are to be met with occasionally.[7]

There is a stalactite in the museum, formed of aragonite with radiate-fibrous structure, from a limestone cave in the Khási hills.

Witherite.—Rolled pieces are said to have been met with in some streams of Rájputána.[8] The mineral is also reported to have been found in Kulu.[9]

Cerussite.—A considerable number of the specimens of Indian galena in the museum are accompanied by more or less cerussite; but the latter mineral has not been reported as occurring in large quantity in many places.

It appears to exist in some quantity in the Ajmere mines.[10] "Choice

[1] Jour. As. Soc. Bengal, Vol. XV, p. lxii.
[2] *Ibid.*, p. 390.
[3] Page 30.
[4] Rájputána Gazetteer, Vol. I, p. 15.
[5] Jour. Roy. As. Soc., Vol. IX, p. 38.
[6] Memoirs, G. S. I., Vol. XXI, p. 136.
[7] F. R. Mallet: *Ibid.*, Vol. V, p. 158.
[8] R. Irvine: Topography of Ajmere, p. 166.
[9] J. Calvert: Kulu; its beauties, &c., p. 72.
[10] C. J. Dixon: Jour. As. Soc. Bengal, Vol. IV, p. 584.

and beautiful specimens of carbonates and sulphates of lead," obtained there, were sent to the Asiatic Society by Colonel Brooke.[1] Carbonate of lead is stated to occur in mass in the bed of the Houndrau river, in Tenasserim.[2] A vein of cerussite, mixed with pyromorphite, has been noticed under the latter mineral; and under minium a mixture of the oxide and carbonate has been alluded to.

II.—Hydrous Carbonates.

Carbonates of sodium.—Sodium carbonate is one of the principal ingredients of *reh*. As previously stated, however, the composition of efflorescence so called varies greatly; in some cases carbonate of sodium is the predominant ingredient, while in others it is entirely absent.[3] An efflorescence of the carbonate is also met with in many non-alluvial parts of the country, as in South Arcot and Trichinopoly, where it occurs on gneiss and cretaceous rocks.[4] Sodium carbonate further exists as a deposit from some lakes in Bikanir,[5] and the Lonar lake, in Berar (Pt. III, p. 492).

In but few instances, however, is the exact composition of salt stated. According to Dr. White, both neutral and sesqui-carbonate (trona) occur in *reh*,[6] and the substance obtained from the Lonar lake is partly sesqui-carbonate, partly neutral carbonate, and partly a mixture of the two.[7]

The neutral carbonate of India doubtless includes both natron and thermonatrite. The former salt is that mentioned by Dr. Irvine as occurring in the Bikanir lakes. According to Dr. Mason, it is abundant in the vicinity of Ava,[8] and it is also mentioned by other writers. In some cases, however, the term may have been used loosely, as a synonym for sodium carbonate generally.

Malachite is seldom altogether absent where other copper ores exist, occurring mainly, as usual, near the surface. In some places it has been found in considerable quantity, but none appears to have been yet obtained of such quality as to fit it for ornamental use.

It appears to form the most abundant ore in the Nellore mines; in that at Ganmanipenta "an immense nest" was discovered.[9] It is said

[1] *Ibid.*, Vol. XXXIII, p. 529.
[2] E. O'Riley: Jour. Indian Archipelago, Vol. III, p. 736.
[3] Page 142, Select. Rec. Govt. India, No. XLII, p. 71.
[4] H. F. Blanford: Memoirs, G. S. I., Vol. IV, p. 215.
[5] R. Irvine: Topography of Ajmere, p. 168.
[6] Select. Rec. Govt. India, No. XLII, p. 83.
[7] Reynolds, Madras Jour. Lit. and Sci., Vol. XVII, p. 14; J. E. Mayer, *Ibid.*, p. 15.
[8] Natural Productions of Burma, p. 32.
[9] B. Heyne: Tracts on India, p. 117. *Vide* mysorin, page 156.

to occur, in some quantity, at the copper mountain, in Bellary;[1] and some handsome specimens of the mineral, in association with azurite, have been obtained at Birman ghát, on the Narbada, in the Narsinghpur district.[2] "Malachite, in solid masses, compact and earthy, seldom fibrous," was found in the mines of Singhbhum.[3] In the Shan States "at Bawyine and Kolen-myo the malachite appears to be of a rich description."[4]

Mysorin.—A dark-coloured ore of copper, obtained by Dr. Heyne at Ganypittah, or Ganmanipenta, in Nellore, where "an immense nest" of it was found,[5] was examined by Dr. T. Thomson in 1813.[6] His description of it is as follows :—

"All the specimens of this ore which I have seen are amorphous; so that, as far as is known at present, it never occurs crystallized. Quartz crystals indeed are imbedded in it abundantly and very irregularly. Sometimes they are single, sometimes they constitute the lining of small cavities to be found in it. These crystals are all translucent. In some rare cases they are colourless; but by far the greater number of them are tinged of a yellowish-red, and some few of them are green. The mineral is likewise interspersed with small specks of malachite; and with dark, brownish red, soft particles, which I found to consist of red oxide of iron.

"The colour varies in consequence of the irregular distribution of these extraneous substances. One specimen, which was the most free from the malachite and the red particles, was of a dark blackish-brown colour. But in general the colour is a mixture of green, red, and brown; sometimes one and sometimes another prevailing. Small green veins of malachite likewise traverse it in different directions.

"The fracture is small conchoidal, and in some parts of the mineral there is a tendency to a foliated fracture. The lustre is glimmering, owing, I conceive, to the minute quartz crystals scattered through it. The kind of lustre is resinous, and on that account and the varieties of colours, this ore has a good deal of the aspect of serpentine.

"It is soft, being easily scratched by the knife. It is sectile. The streak reddish-brown. The specific gravity 2·620.

"It effervesces in acids and dissolves, letting fall a red powder. The solution is green or blue, according to the acid, indicating that it consists chiefly of copper."

The result of Dr. Thomson's analysis was as follows :—

Carbonic acid	16·70
Peroxide of copper	60·75
Peroxide of iron	19·50
Silica	2·10
Loss	·95
	100·00

[1] Bellary Manual, p. 93.
[2] V. Ball: Records, G. S. I., Vol. VII, p. 62.
[3] M. E. Stœhr: *Ibid.*, Vol. III, p. 88.
[4] G. A. Strover: Metals and Minerals of Upper Burma, p. 2.
[5] Tracts on India, p. 117.
[6] Phil. Trans., 1814, p. 45; Tracts on India, p. 441.

The oxide of iron and silica he regarded as mechanically mixed, and he therefore considered the ore to be an anhydrous carbonate of copper, and a new mineral species. It is described (in an abridged form from the above-mentioned paper) in his Outlines of Mineralogy (7th edition, 1836) as anhydrous bicarbonate of copper. In most works on mineralogy, of a date subsequent to Dr. Thomson's, the ore is alluded to as a doubtful species under the name of mysorin.[1]

Some years ago a parcel of a hundredweight, or more, of copper ore from the same locality, Ganmanipenta, and exhibiting such a general agreement in external characters, with Dr. Thomson's mysorin, that there can be no reasonable doubt as to its being the same ore, was received at the museum, and was examined by the present writer.[2]

The ore, as sent, occurred in irregular broken pieces of various sizes up to about 3 inches diameter. It was a most heterogeneous mixture, made up of over half a dozen different minerals, some of which were, however, much more abundant than others. Taken roughly in the order of their relative abundance, there were visible to the naked eye, or with a lens—

The dark reddish-brown ore in question.
Malachite.
Chrysocolla.
Quartz.
Yellowish-brown ochre.
Chalcocite.
Calcite.
Bornite.

The most homogeneous portions of the first-named had to the naked eye a dark reddish-brown colour, but viewed with a lens they were seen to be finely mottled in dark brownish-red and green. A thin section, which to the naked eye had a reddish-brown colour by reflected light, when viewed with a lens by transmitted light, showed this mottled structure still more plainly. The relative proportion of the two colours varied greatly. Occasionally a patch was found in which the green was almost absent. It was but rarely that one found a surface of a quarter of an inch square that was not intersected by thin green seams of malachite and chrysocolla, which traversed the ore in different directions. Specks of chalcocite were also visible, and, very occasionally, those of bornite. The ore contained a few small cavities, partially filled with red ochreous oxide of iron.

[1] From Mysore. The country, however, in which it was found, lies considerably to the east of the Mysore territory of the present day.

[2] Records, G. S. I., Vol. XII, p. 166.

The fragments selected for analysis yielded (after drying at 100° C.)—

Copper equiv. to ·56 of S.	2·22
Copper calculated as cupric oxide	61·46
Ferric oxide (with tr. of Al_2O_3)	6·74
Lime	·26
Baryta	·55
Carbonic acid	15·18
Silicic acid	4·39
Phosphoric acid	trace
Sulphuric acid	·29
Sulphur	·56
Water [1]	9·02
	100·67

figures which are equivalent to—

		Cu.	CuO.	Fe_2O_3	CaO.	BaO.	CO_2	SiO_2	SO_3	S.	H_2O.
Malachite	77·02	...	55·65	...	...	...	14·98	...	...	...	6·39
Calcite	·46	...	...	...	·26	...	·20	...	...	...	...
Chrysocolla	12·83	...	5·81	...	...	...	...	4·39	...	...	2·63
Barite	·84	...	...	...	...	·55	...	...	·29	...	...
Chalcocite	2·78	2·22	...	...	...	...	...	...	...	·56	...
Ferric oxide	6·74	...	...	6·74	...	...	...	...	...	...	...
	100·67	2·22	61·46	6·74	·26	·55	15·18	4·39	·29	·56	9·02

After deducting the cupric oxide and water equivalent to the silica, and the carbonic acid equivalent to the lime, there remains a residue of, water 6·39, carbonic acid 14·98, cupric oxide 55·65; quantities which have the oxygen ratio of 1 : 1·92 : 1·97; the oxygen ratio in typical malachite being 1 : 2 : 2. It is clear, therefore, that the ore is an impure malachite, owing its dark colour to admixture with ferric oxide and chalcocite. Some specimens, indeed, of the Ganmanipenta ore, which are seen to be impure malachite by the eye, have a dark colour owing to a smaller admixture of the same kind.

Azurite occurs, like malachite, as a result of the superficial alteration of other ores. It is, however, much less common. Handsome specimens have been obtained at Birman ghát,[2] and the mineral was also found in the mines of Singhbhum.[3]

[1] The amount of water was determined by direct weighment.

[2] *Vide* malachite, page 156.

[3] C. Durrschmidt: Copper Mines of Singhbhum, p. 20.

VI.—Hydrocarbon compounds.

Petroleum exists in Upper Burma, Pegu, Arakan, Upper Assam, several parts of the Punjab, Baluchistán, and Afghánistán. In some of the places mentioned it is known to occur in large quantities, and in nearly all of them the oil has been worked to a greater or less extent. The subject has been treated in detail by Mr. Ball in the third part of the present work (p. 124).[1]

Native paraffin.—Dr. Waldie has recorded having examined specimens of native paraffin "which had been found in the surface of the ground in some parts of Burma." He was of opinion that it had been separated, through natural causes, from petroleum,[2] which, in Upper Burma, contains a large amount, some 10 per cent., of the substance in question.[3]

Fossil wax ?—In connection with the vegetable remains included in the fresh-water intertrappean beds of Bombay island, a small amount of coaly matter is found. "Also portions of mineral resin, resembling 'hatchetine,' or mineral tallow, are occasionally met with; and invariably calcspar in company with both these substances. The mineral resin is sub-granular, like bees'-wax, and breaks, but is too waxy to be pulverized; it floats in water, but sinks in alcohol; is translucent, of a weak pearly lustre, and of the colour of bees'-wax; feels greasy, and is inodorous; dissolves readily in turpentine, but not in ether or alcohol; becomes soft at a temperature just below 212° Fahr., but does not melt in boiling water; when exposed to a greater heat becomes very fluid, but does not take fire until the temperature is raised, when it burns away with a bright flame, leaving no residue."[4] The substance does not altogether resemble hatchetine in the action of solvents, and differs widely from it in melting point, that of the latter material being 46° C. (114°·8 F.).

Amber.—The only locality in India where amber is known, with certainty, to occur, is the Hukung valley, in Upper Burma, where it is found, in some quantity, associated with lignite (Pt. III, p. 57).

Fossil resin.—A fossil resin, partly dark and pitchy, partly light

[1] See also Records, G. S. I., Vol. XIX, p. 185 (H. B. Medlicott); and, with reference to Baluchistán, *Ibid.*, p. 204 (R. A. Townsend).

[2] Proc. As. Soc. Bengal, 1866, p. 73.

[3] W. De la Rue: Phil. Mag., 4th Ser., Vol. XIII, p. 513.

[4] H. J. Carter: Jour. As. Soc. Bombay, Vol. IV, p. 176.

yellow and transparent, which becomes electric when rubbed, and possesses a specific gravity of 1·037, was found, by Dr. Rink, in (tertiary?) sandstone on Milu, in the Nicobars. It is very brittle; insoluble in alcohol; partially soluble in hot ether; unaltered by hot solution of potash, and when burnt gives a smell similar to that of amber.[1]

The cretaceous coal of Assam is characterized by frequently containing numerous specks and small nests of yellow or brownish, transparent or translucent, brittle resin.[2] Resin of similar appearance is abundant in the coal of the Lenya river, in Tenasserim,[3] and has been lately found, by Mr. Jones, in that of Kale, in the Chindwin valley, Upper Burma.

Hircine.—This name was given, by Mr. Piddington, to a fossil resin which is said to occur in the same ground as the petroleum wells of Upper Burma, and to be obtained at a depth of 100 to 200 feet below the surface. He described it as brown on the exterior, and brown-yellow internally; opaque, but slightly translucent on the edges; tough and elastic; fracture hackly in small pieces, but conchoidal in the large; specific gravity about 1·2; melts in the flame of a candle; when ignited, it burns, and leaves a carbonaceous residue, which has a very peculiar semi-animal odour (whence the name, from *hircus*, a goat); softens when boiled in water, and the powder gives off the odour alluded to with the steam; slightly soluble in cold alcohol; about one half dissolves in boiling alcohol, yielding a gold-yellow solution; dissolves in sulphuric acid, forming a blood-red solution which, on dilution, acquires "a dull, dirty, troubled white colour."[4]

Coal exists in India in great abundance; in formations of various ages; and in a very large number of fields, scattered over an immense area. The subject, however, can scarcely be considered a mineralogical one. It has been discussed in detail, from a geological point of view, in the first and second parts, and, from an economic one, in the third part, of the present work.

[1] Select. Rec. Govt. India, No. LXXVII, p. 128.
[2] H. B. Medlicott: Memoirs, G. S. I., Vol. VII, p. 175.
[3] T. Oldham: Select. Rec. Govt. Bengal, No. VI, p. 39.
[4] Jour. As. Soc. Bengal, Vol. XXI, p. 76; Vol. XXII, p. 279.

Appendix A.

Brucite.—Within the last month a specimen has been received of a mineral recently discovered in Afghánistán. The exact locality was not mentioned by the British Agent at Kabul, by whom the specimen was originally sent. It consists of white, translucent, silky, elastic fibres, some 6 to 8 inches in length, which proved, on examination, to be *nemalite*, or fibrous brucite. An analysis made in the Geological Survey Laboratory, by Mr. T. Blyth gave—

		Oxygen ratio.	
Magnesia	60·95	24·38	26·85
Ferrous oxide	11·14	2·47	
Water	29·32		26·06
Insoluble in HCl	·38		
	101·79		

corresponding to the formula $Mg(OH)_2$ or $MgO.H_2O$. The specimen is remarkable from the unusually large proportion of ferrous oxide, by which a part of the magnesia is replaced.

Appendix B.

List of secondary minerals that have been found in the Deccan trap.

Galena occurs very sparingly in a small quartz-vein in the trap of the Gir hills in Káthiawár (Memoirs, G. S. I., Vol. XXI, p. 134). Chalcopyrite occurs very sparingly with the galena just mentioned.

Rock crystal, p. 63.
Milky quartz, p. 66.
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Glauconite, p. 127.
Calcite, p. 147.
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N.B.—Synonyms are indicated by the letter *s.*; *e.g.* Analcite, *s.* Analcime.

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PLATE I.

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„ 2. Sapphire; 2P2.0R. Zánskár, Káshmir; p. 41.

„ 3. Sapphire; $\frac{8}{3}$P2.0R. Zánskár; p. 41.

„ 4. Sapphire; $\frac{8}{3}$P2.0R. (crystal flattened owing to the imperfect development of 4 of the pyramidal faces). Zánskár; p. 41.

„ 5. Sapphire; 4P2.0R. (crystal flattened as in fig. 4). Zánskár; p. 41.

„ 6. Ruby; ∞P2.0R.R. Upper Burma; p. 43.

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„ 8. Ruby; 0R.∞P2. $\frac{4}{3}$P2.R. Upper Burma; p. 43.

„ 9. Ruby; ∞P2.0R.R. Jágdalak, Afghánistán; p. 45.

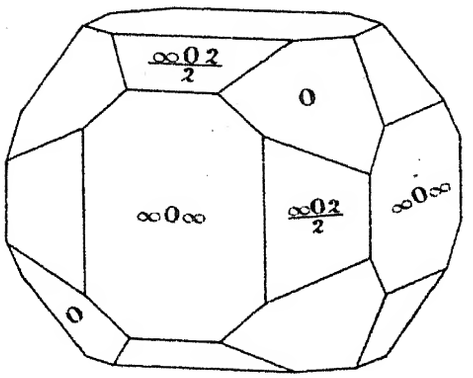
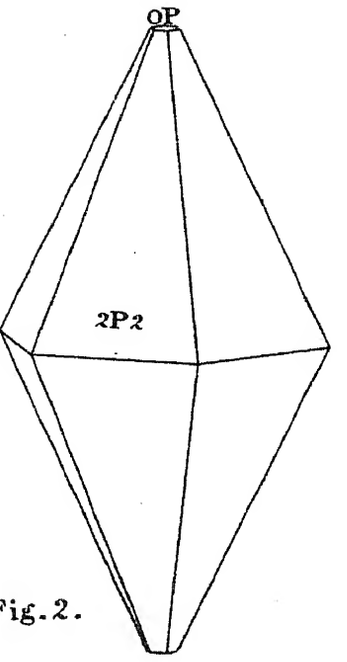


Fig. 1.



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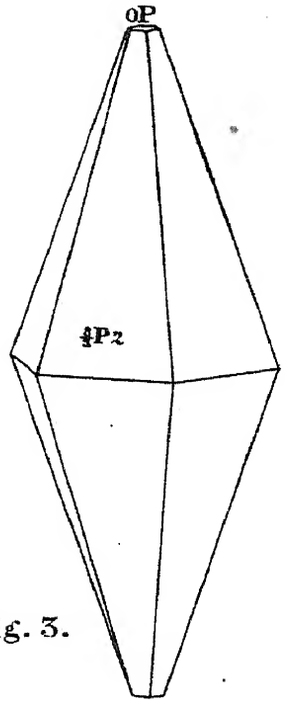
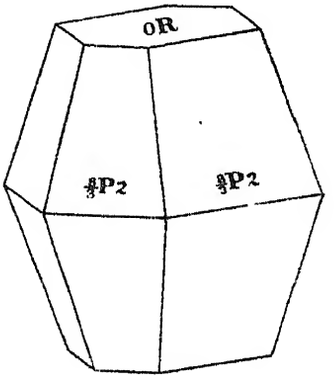


Fig. 3.



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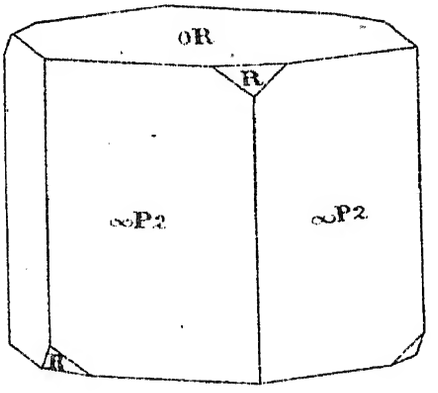

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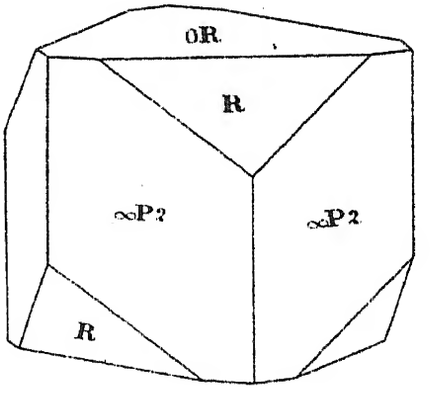

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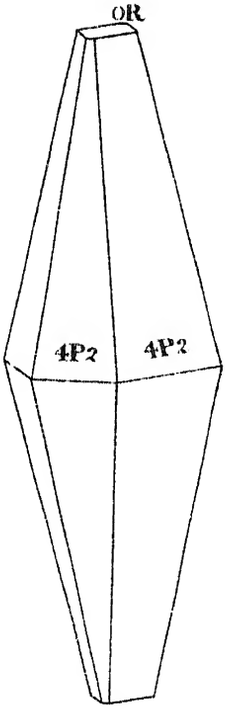

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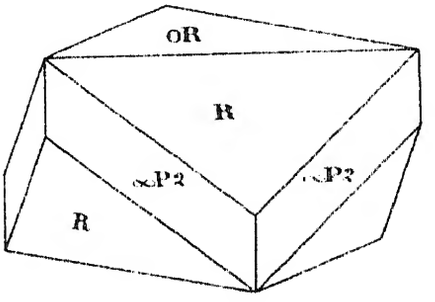

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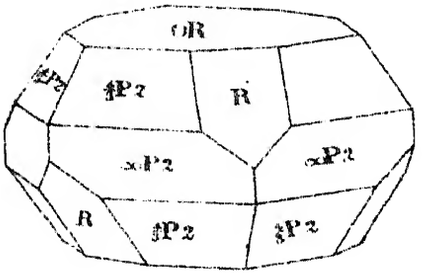

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PHOTOZINCOGRAPHED AT THE SURVEY OF INDIA OFFICES CALCUTTA, APRIL 1887.

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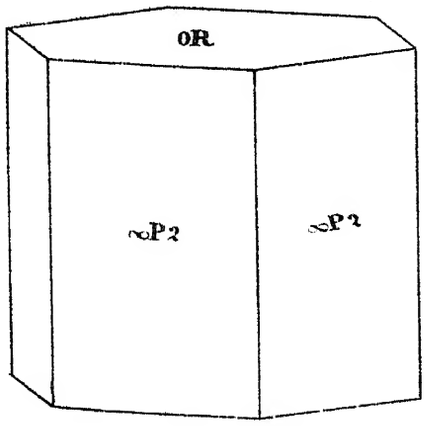

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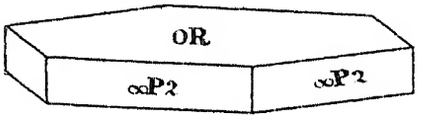

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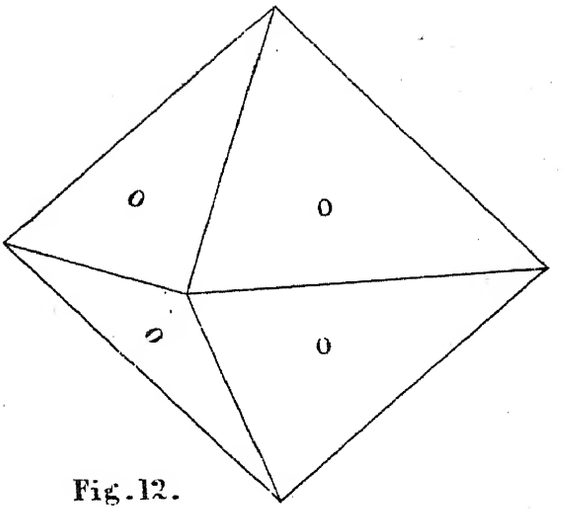

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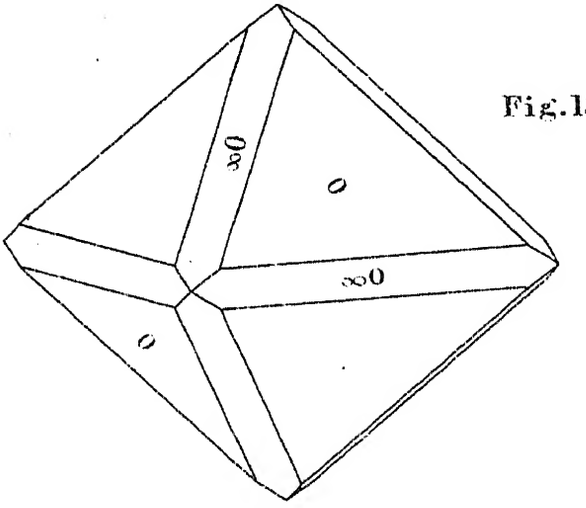

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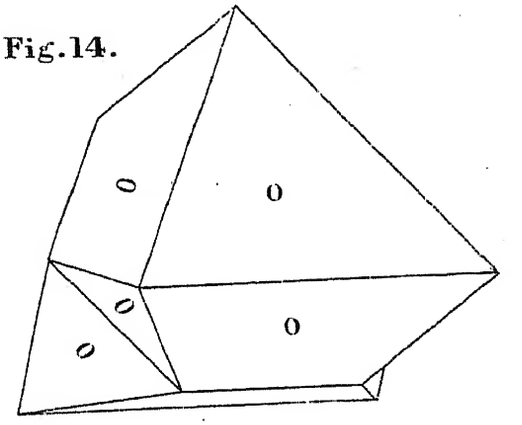

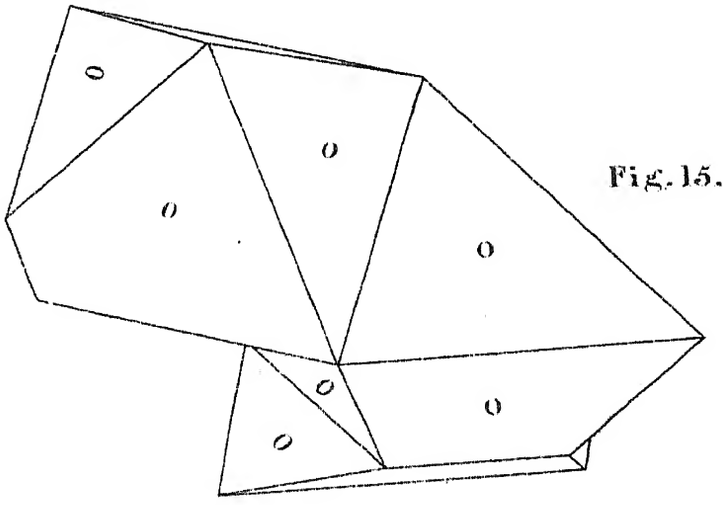

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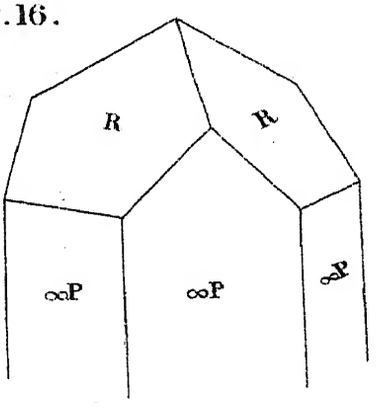

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„ 19. Quartz; R.—R. Salt range; p. 65.
„ 20. Quartz; R.—R. Salt range; p. 65.
„ 21. Quartz; R.—R.∞P. Salt range; p. 65.
„ 22. Apophyllite; 0P.∞P∞.P. Western Ghâts; p. 118.
„ 23. Apophyllite; 0P.∞P∞.P. Western Ghâts; p. 118.
„ 24. Apophyllite; 0P.∞P∞.P.∞P. Western Ghâts; p. 118.
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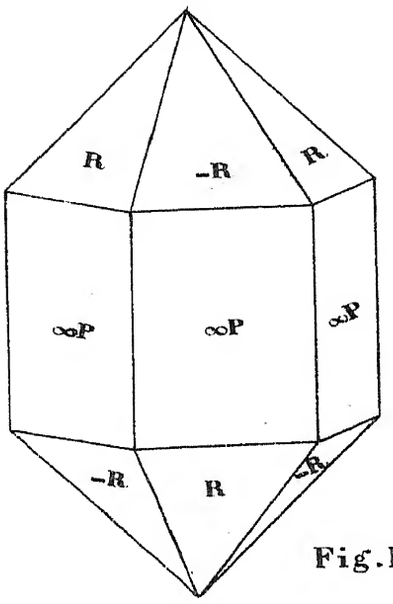
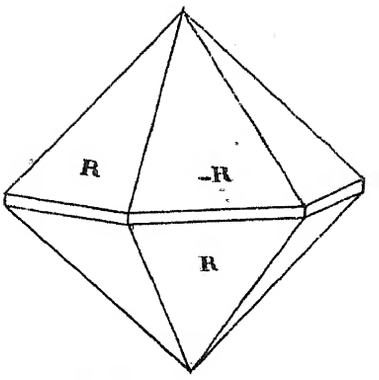


Fig.17.



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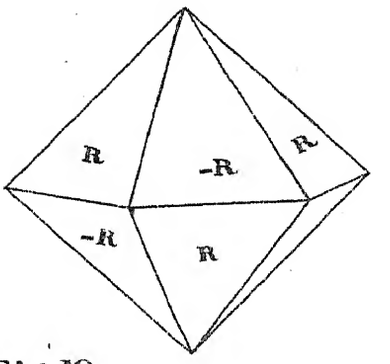

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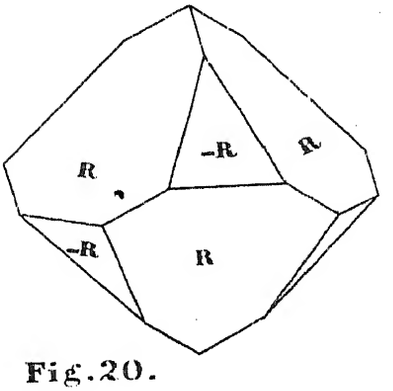

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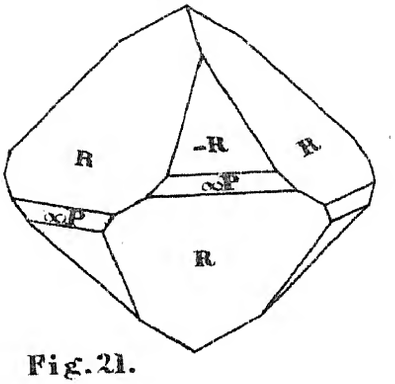

Fig.21.

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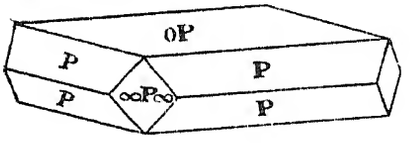

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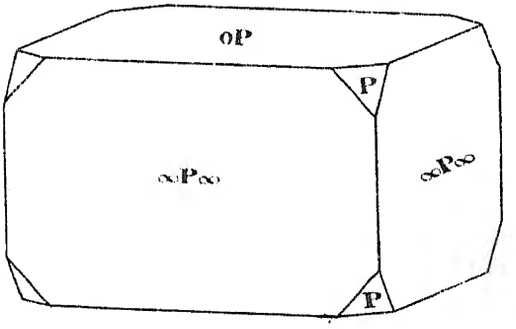
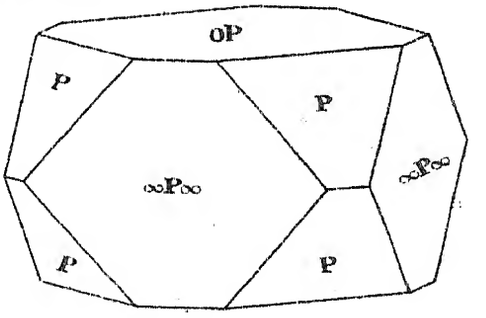


Fig.23.



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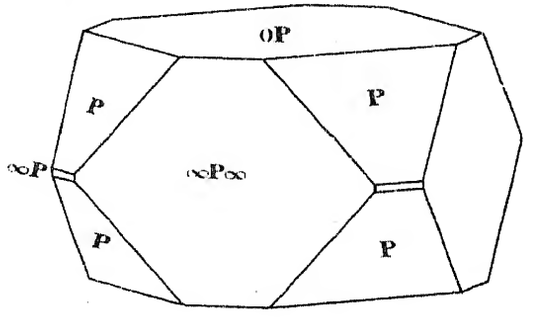

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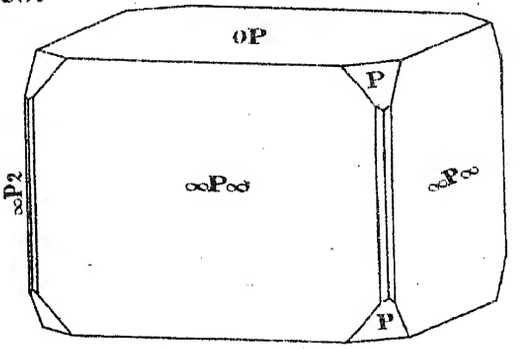

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PLATE IV.

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„ 28. Apophyllite; P. ∞P∞. 0P. Ahmadnagar; p. 118.

„ 29. Apophyllite; P. ∞P∞. Ahmadnagar; p. 118.

„ 30. Apophyllite; ∞P∞. P. ∞P2. 0P. Poona. (After Schrauf); p. 118.

„ 31. Stilbite; ∞P̆∞. ∞P̄∞. P. Western Ghâts; p. 123.

„ 32. Stilbite; ∞P̆∞. ∞P̄∞. P. ∞P. Western Ghâts; p. 124.

„ 33. Stilbite; ∞P̆∞. ∞P̄∞. P. ∞P. $\frac{5}{2}$P$\frac{5}{2}$. Western Ghâts; p. 124.

„ 34. Stilbite; ∞P̆∞. ∞P̄∞. P. ∞P. $\frac{5}{2}$P$\frac{5}{2}$. 0P. Western Ghâts; p. 124.

„ 35. Heulandite; ∞P̆∞.—2P̆∞.2P̆∞.0P.∞P.—P.P̆∞. Western Ghâts; p. 127.

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„ 37. Glauberite; 0P.—P. ∞P̆∞. ∞P. Salt range. (According to Schimper); p. 142.

„ 38. Glauberite; 0P.—P.∞P̆∞.∞P.—$\frac{1}{2}$P. 2P̆∞. $\frac{2}{3}$P̆∞. Salt range. (According to Schimper); p. 142.

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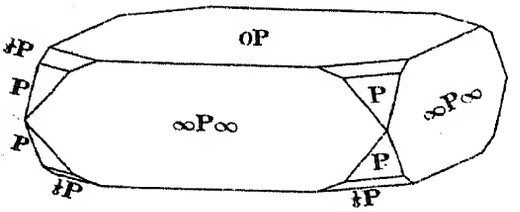


Fig. 27.

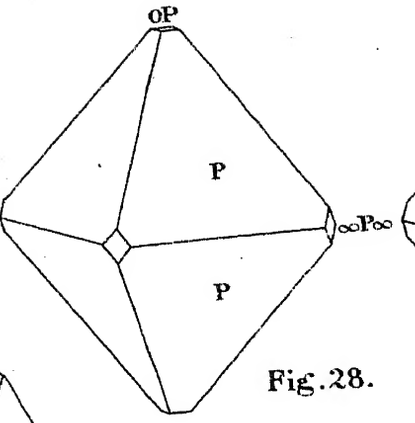
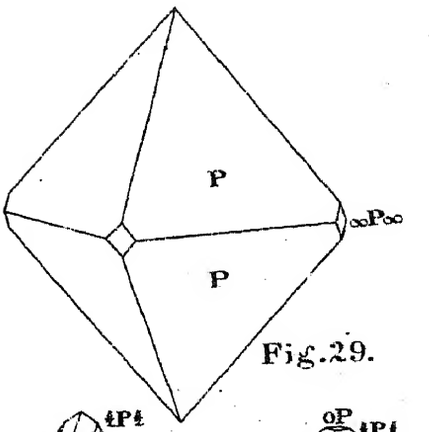


Fig. 28.



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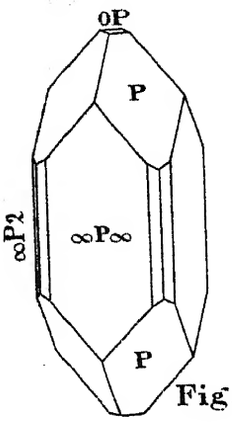

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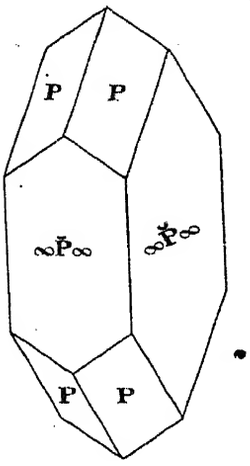

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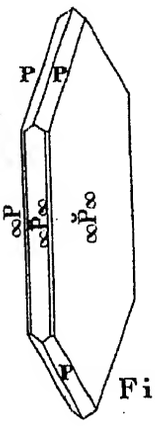

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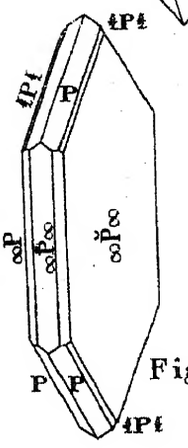

Fig. 33.

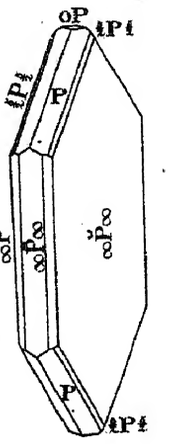

Fig. 34.

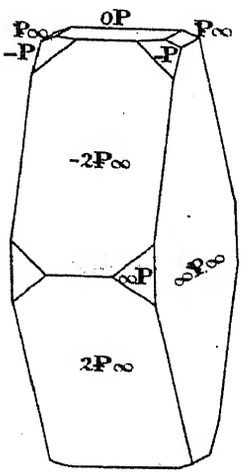

Fig. 35.

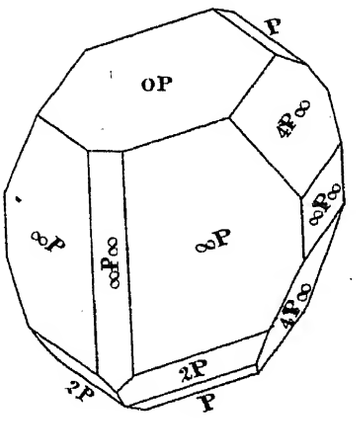

Fig. 36.

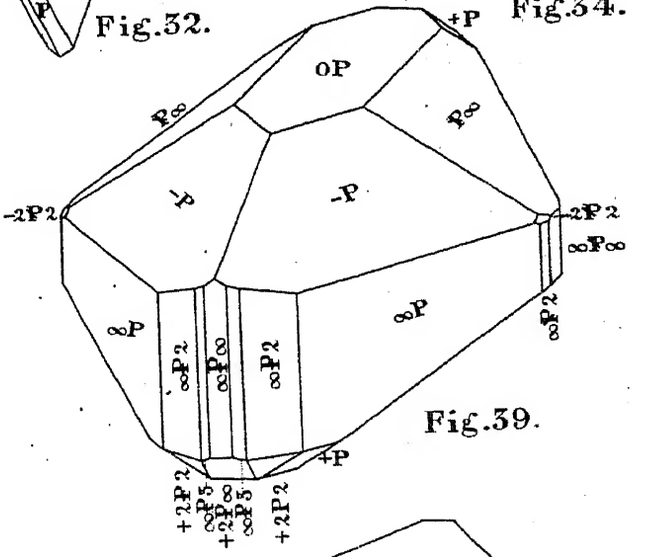

Fig. 39.

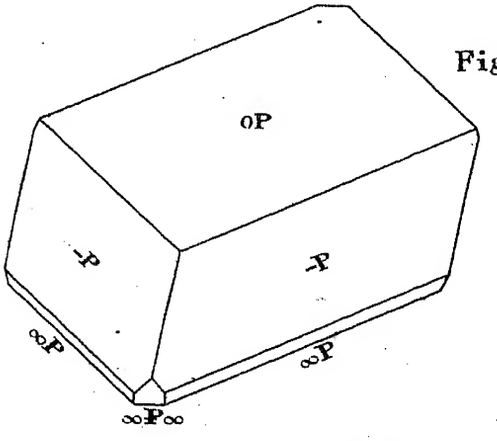

Fig. 37.

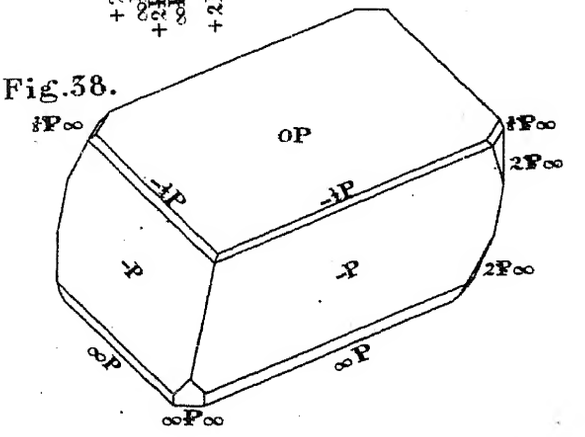

Fig. 38.

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